PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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P. D. EDWARDS, EDITOR

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Spring Meeting
SPRING MILL STATE PARK
May 3 and 4, 1940

Fifty-Sixth Annual Meeting
BALL STATE TEACHERS COLLEGE
November 14, 15 and 16, 1940

MAY, 1941
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Reprints of technical papers in recent volumes can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

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OFFICERS AND ELECTED COMMITTEES FOR 1940

OFFICERS

President, FRANK WALLACE, Dept. of Conservation, Indianapolis.
Vice-President, S. S. VISHER, Indiana University, Bloomington.
Secretary, W. P. ALLYN, Indiana State Teachers College, Terre Haute.
Treasurer, W. P. MORGAN, Indiana Central College, Indianapolis.
Editor, PAUL WEATHERWAX, Indiana University, Bloomington.
Press Secretary, WILL E. EDINGTON, DePauw University, Greencastle.
Trustees Academy Foundation, JOHN S. WRIGHT, Eli Lilly and Company (term expires 1940); F. B. WADE, Shortridge High School (term expires 1943)
Committee for Bonding Trustees, H. L. BRUNER, Butler University. Indianapolis; W. A. COGSHALL, Indiana University, Bloomington.
Research Grant Committee, A. L. FOLEY, Chairman, Indiana University (term expires 1941); H. W. ENDERS, Purdue University (term expires 1940); E. G. MAHIN, University of Notre Dame (term expires 1942); M. S. MARKLE, Earlham College (term expires 1944); JOHN S. WRIGHT, Indianapolis (term expires 1943); FRANK N. WALLACE, Indianapolis (ex officio); W. P. ALLYN, Indiana State Teachers College (ex officio).

DIVISIONAL CHAIRMEN

Anthropology, PAUL WEER, 1808 N. Delaware Street, Indianapolis.
Bacteriology, DONA GRAAM, Terre Haute.
Botany, RALPH KRIEBEL, Soil Conservation, Bedford.
Chemistry, KARL MEANS, Butler University.
Geology and Geography, WILLIAM D. THORNBURY, Indiana University.
Mathematics, CORA HENNEL, Indiana University.
Physics, J. F. MACKELL, Indiana State Teachers College.
Psychology, R. A. ACHER, Indiana State Teachers College.
Zoology, W. A. HIESTAND, Purdue University.

EXECUTIVE COMMITTEE

(Past Presidents, Officers, Divisional Chairmen, and Chairmen of Standing Committees)

R. A. Acher, W. P. Allyn, F. M. Andrews, J. C. Arthur, C. A. Behrens, W. M. Blanchard, W. S. Blatchley, H. L. Bruner, S. Burrage, O. B. Christy, W. A. Cogshall, Stanley Coulter, E. R. Cumings, J. J. Davis, C. C. Deam, W. E. Edington, H. E. Enders, A. L. Foley, R. C. Friesner, Dona Graam, W. G. Gingery, Cora Hennel, R. Hessler, W. A. Hiestand, Ralph Kriebel, Eli Lilly, M. W. Lyon, Jr., J. F. Mackell, E. G. Mahin, M. S. Markle, E. S. Martin, Karl Means, W. J. Moenkhaus, W. P. Morgan, D. M. Mottier, J. P. Naylor, H. A. Noyes, C. M. Palmer, F. Payne, R. R. Ramsey, L. A. Test, William D. Thornbury, S. S. Visher, F. B. Wade, F. N. Wallace, Paul Weatherwax, Paul Weer, J. S. Wright, T. G. Yuncker.

STANDING COMMITTEES

(Appointed by the President, Chairman of Each Committee Named First)

Auditing: E. S. Martin, William Johnson.

Biological Survey: C. M. Palmer, S. R. Esten, M. W. Lyon, Jr., B. E. Montgomery, Dorothy Parker, B. H. Smith, Winona H. Welch.

Library: Walter G. Gingery, Ray C. Friesner, Nellie M. Coats.

Membership: L. A. Test, A. R. Bechtel, Floyd E. Beghtel, O. B. Christy, C. A. Deppe, F. R. Elliott, A. R. Eikenberry, R. E. Girton, D. L. Harmon, W. A. Jamieson, David Johnson, G. D. Klopp, F. A. Loew, M. S. Markle, R. E. Martin, H. G. Nester, Theodore Just, J. L. Riebsomer, W. D. Thornbury, S. W. Witmer.

Program: O. B. Christy, P. D. Edwards, Ralph Kriebel, C. R. Gutermuth, D. E. Miller, and Divisional Chairmen.

Publication of Proceedings: Paul Weatherwax, E. S. Conklin, J. J. Davis, C. A. Behrens, F. B. Wade, M. E. Hufford.

Relation of Academy to State: J. S. Wright, Stanley Coulter, E. Y. Guernsey, Harry J. Reed, D. A. Rothrock, F. N. Wallace.

Representative on A.A.A.S. Council: Howard E. Enders.

Nominations: John S. Wright, C. L. Porter, C. A. Malott.

Junior Academy of Science: H. E. Enders, F. E. Beghtel, F. J. Breeze, O. B. Christy, C. F. Cox, F. B. Wade, P. D. Wilkinson, M. M. Williams.

MINUTES OF THE EXECUTIVE COUNCIL

SPRING MILL STATE PARK, MAY 3, 1940

The Executive Council was called to order by the President, Frank N. Wallace, in the Lounge Room of the Spring Mill Inn at 4:45 P.M.

Officers and committees reported as follows:

Academy Trustee. F. B. Wade reported that the Trustees had authorized a research grant of $25.00 to Dr. Visher, a grant made by the Research Grant Committee of the Academy at the fall meeting. Three grants were made: $100.00 to Dr. Headlee at Purdue, $50.00 to Dr. Mackell, Indiana State Teachers College, and $25.00 to Dr. Visher, Indiana University. The first two were covered by a $150.00 refund from the A.A.A.S. and the last of $25.00 to Dr. Visher to be provided from the Academy Foundation Fund.

It was indicated that a complete statement of the Foundation's assets would appear in the Proceedings.

Treasurer. The Treasurer stated that expenditures of the Academy were rapidly overtaking receipts. A discussion that followed emphasized two points: first, that membership should be increased, and second, that the expenditures of the Academy should be budgeted.

It was moved and seconded that a committee be appointed annually to set up a budget for the Academy—the budget to be approved by the Executive Council and then to be adhered to during that fiscal year.

Biological Survey. The chairman gave no report but indicated that a definite plan for future action was in the making.

Editor. Dr. Weatherwax stated that one-half the galley proof was back from the printer and that the Proceedings should be completed by June 1, in time to make payment out of this year's appropriations. All costs of printing were calculated at $1500, thus making possible a transfer of $250 for binding at the State Library.

Library Committee. It was pointed out that the binding of all materials, property of the library, is now carried on by Miss Nellie Coats. Dr. Friesner informed the committee that much of the material published in the first fifty volumes of the Proceedings is lost, as it now stands, without an index for these volumes. It was estimated that the total cost of such an index would approximate $850.

A motion was carried that a committee be appointed to investigate the preparation of the fifty-volume index and that the committee be given power to act if funds could be ascertained aside from the Academy funds. The President appointed the following committee: Ray C. Friesner, Chairman, Paul Weatherwax, W. P. Morgan, and Nellie Coats.

Membership Committee. Thirty-two applications for membership were submitted and unanimously elected.

Dr. Weatherwax moved that all new members be mailed the Proceedings published during the year in which the members were elected. The motion was carried.

It was also moved and carried that one hundred extra volumes of the Proceedings be published to cover this need.

Research Grant Committee. The Secretary reported that the three grants awarded by the Research Grant Committee had been paid to the grantees. The $100 to Dr. Headlee of Purdue and $50 to Dr. Mackell of Indiana State Teachers College were paid from the $150 refund from the A.A.A.S., and the $25 to Dr. Visher had been paid from the Academy Foundation Funds.

After a brief discussion, it was moved that the Division of Archaeology be hereafter known as the Division of Anthropology. The motion was carried.

A discussion followed concerning college students participating in groups at the Academy meetings on a basis somewhat comparable to the Junior Academies. It was suggested that effort be made toward this end as a test case at the Fall meeting at Muncie this year.

The President appointed Dr. Edington and Dr. Friesner on the Resolution Committee and the meeting adjourned.

An interesting program was presented following the Academy dinner. E. Y. Guernsey discussed the history and development of the Spring Mill State Park and Ralph Kriebel outlined the work of federal and state agencies in that area. Clyde A. Malott and Ray C. Friesner gave instructional talks on the geology and botany of that region. Bird hikes, field trips, and trips through the park were scheduled for the following morning.

PROGRAM OF THE WINTER MEETING

BALL STATE TEACHERS COLLEGE
November 14-16, 1941

THURSDAY, NOVEMBER 14
7:30 p. m.

Meeting of the Executive Committee.

FRIDAY, NOVEMBER 15
9:00 a. m. General Session

Selections by the Ball State Teachers College Orchestra. Professor Claude E. Palmer, Conductor.

Address of Welcome. President L. A. Pittenger, Ball State Teachers College.

Response. President Frank N. Wallace.

Business Session.

Necrology. Will E. Edington, DePauw University.

"Archaeology at the Angel Mounds Site." Glenn A. Black, Newburgh, Indiana.

"Life and Customs among the Samoans." T. G. Yuncker, DePauw University.

1:00 p. m. Sectional Meetings

6:00 p. m. Annual Dinner

Selections by Men's Glee Club. Ball State Teachers College.

Business Session.

President's Address. "Fighting the Japanese Beetle in Indiana," Frank N. Wallace, State Entomologist.

SATURDAY, NOVEMBER 16
10:00 a. m. and 2:00 p. m.

Junior Academy of Science, Program, Business Meeting, and Exhibits.

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

BALL STATE TEACHERS COLLEGE, NOVEMBER 14, 1940

The Executive Committee of the Indiana Academy of Science met in the West Lounge of the Arts Building at Ball State Teachers College, Muncie, November 14, 1940. The meeting was called to order by President Wallace at 8 p. m. and the minutes of the council meeting at Spring Mill State Park, May 3, 1940 were read and approved. Officers and committees reported as follows:

Academy Trustee. Mr. John S. Wright submitted the following report of the Foundation funds of the Academy for 1939-40, which was accepted.

Receipts

Balance from previous year	$466.20
Total receipts	232.50
Plus cash balance from sale of UST4s	266.91
Total	$965.61

Expenditures

S. S. Visher as per order of Research Committee	$25.00
Balance in Indiana National Bank Savings Account	940.61
Total	$965.61

Assets of the Fund as of November 1, 1940

United States Treasury Bonds par	$1,200.00
United States Savings Bonds—face $5,000.00, 1950—cost 1-20-40	3,750.00
Consolidated Federal Farm Loan Bonds par	1,500.00
Consolidated Federal Farm Mortgage Bonds par	1,000.00
Muncie Masonic Temple Assn. First Mortgage Bond	200.00
Standard Oil Company of Indiana, 6 shares at $25.00	150.00
Balance in Indiana National Bank Savings Account	940.61
Total Assets	$8,740.61

Auditing Committee. The chairman stated that a complete audit of the Academy books would not be made until the year's transactions of the Academy had all been entered, and that a complete audit would then be made and included in the published Proceedings.

Biological Survey. A rather comprehensive survey of the activities of the committee was submitted. A note of appreciation was expressed to members of the Academy, the State Department of Conservation, and to Mr. Deam for the publication of the Flora of Indiana. Special mention was made of the fine tribute paid to the high calibre of this work by Dean Stanley Coulter in the foreword to the book.

Some five hundred additional state and county records of flowering plants and ferns had been added to the list. Further studies are in progress on the mosses, liverworts, lichens, myxomycetes, and algae. Also additional records are being made on the dragon flies and Coleoptera.

It was stated that until the Academy may see fit to appropriate funds for the publication of the bibliography of Indiana biota, the work of the committee must be confined to arousing interest in further research on the fauna and flora of the state.

The committee recommended that a sum of fifty dollars be set aside annually by the Academy for biological survey work under the direction of the committee.

Insomuch as a fifty dollar annual grant was requested and since the funds of the Academy were henceforth to be budgeted, the President referred the report to the Research Grant Committee for consideration.

Bonding Committee. The committee reported as follows: In accordance with the action of the Executive Committee, the bonds of the two trustees of the Academy have been increased, making the total amounts and costs as indicated:

Treasurer	$2,000 cost	$5.00
Trustee	5,000 cost	10.00
Trustee	5,000 cost	10.00
Total cost annually		$25.00

Investigation was made on decreasing rates per thousand on increased denominations of bonds, but it was found that the Hartford Company charges a uniform rate per thousand up to thirty thousand dollars.

The report was accepted and cost of bonding ordered paid.

Editor. The Editor submitted the following report:

The delivery of Volume 49 of the Proceedings was delayed until late in August because of the failure of the printer to meet the time requirements of the specifications. All work of editing and proof reading was done with sufficient promptness to make possible the completion of the work by June 1.

The following statistics apply to the volume:

Number of copies bound in cloth	1,000
Number of copies in paper covers	600
Number of pages published	283
Total cost of manufacture	$1,198.66
Cost of reprints ordered for Academy or furnished gratis	33.31
Cost of editing for assistant, postage, supplies	169.65
Total cost of publication	$1,401.62

In view of the condition of the treasury, the cost of publication was held as low as possible, and the only part of the cost of manufacture charged to the Academy was the bill of $168.00 for engraving. The returns from authors for reprints will cancel this amount. The cost of printing as estimated at the end of the fiscal year proved to be $57.70 more than the actual cost, and this amount of our appropriation necessarily reverted to the state. The cost per printed page for this volume was considerably less than last year. A part of this difference is due to the variable nature of the composition of material of the kind published, but a part of it came from the new plan of awarding contracts for state printing.

The report of the Editor was accepted.

Library Committee. In the absence of the chairman, Dr. Friesner indicated that the library was receiving only about 58% of the exchanges

received in the past because of the lack of exchange for foreign publications. The problem of financing the binding of materials at the library was referred to the budget committee.

Membership Committee. It was stated that a total of thirty-six applications for membership had been submitted and prospects of more were in the offing. It was emphasized that every Academy member might well consider himself a member of the committee and feel responsible for interesting all good prospects in the aims and objectives of the Academy.

Press Secretary. The Secretary reported as follows:

The Virginia Academy of Science is conducting a questionnaire as to what state academies are doing and should do to make their services to the state more effective. The Press Secretary received such a questionnaire and offered the following suggestions: A state academy should stress the importance of the scientific attitude toward scientific matters coming before the Legislature. It should endeavor to secure funds to insure the carrying on of certain research projects not specifically provided for otherwise by universities, colleges, or the state. These projects may be individual research or general research that has been neglected in the state, such as wild life, etc. The Academy should attempt through membership in the Academy the cooperation of all scientific men of the state, including medical men, engineers, industrialists, etc. Thus the Academy will be in a better position to influence legislation that will protect the resources of the state. The Academy through its membership should insure greater sympathy and understanding, and a closer cooperation between the state supported institutions and similar private institutions carrying on scientific work. The Academy should insist on the scientific approach to many of the social problems confronting the state. Also all data should be treated in a scientific manner by trained workers, and the Academy should insist that scientific findings be acted on without regard for political expediency or exploitation.

The usual reports of the Press Secretary to Science and the newspapers for the past winter and spring meetings have been made. Publicity of the Terre Haute meeting was secured through the fine cooperation of the Publicity Director of the Indiana State Teachers College.

The report was accepted.

Relations of the Academy to the State. John S. Wright stated that the usual request for $1500.00 from the State as an aid in financing the publication of the Proceedings had been made, and that it was anticipated that this amount would be granted.

Research Grant Committee. Dr. Foley regretted that only one application for a research grant had been submitted to the committee and this request came from the State of Ohio. It was recommended that the request be deferred for further consideration and investigation.

A brief report was made on the progress of the work of grantees of the previous year. A grant of $25.00 to Dr. S. S. Visher had been used for student help in preparing maps on drouth studies in Indiana. A grant of $50.00 to J. F. Mackell for studies of the floating needle and a grant of $100.00 to W. H. Headlee for studies on human intestinal parasites in urban and rural communities, were not all spent by the grantees. The grantees requested that the remainder of the funds be spent in furthering these studies.

It was also stated that a previous grant of $150.00 to H. T. Briscoe had been expended for a standard-condenser and accessory equipment

for the study of dielectric constants of certain organic compounds and that Dr. Briscoe respectfully requested that he be permitted to continue the use of this apparatus in further studies.

The requests by the grantees to utilize the unused portions of the grants and equipment for further research in the respective fields were approved by the committee.

Treasurer. The Treasurer gave a tentative financial report for the Academy as of January 1, to October 31, 1939.

His final report, approved by the Auditing Committee at the end of the fiscal year, 1940, was as follows:

Receipts

Balance on hand January 1, 1940	$202.96	
Dues and initiation fees	809.00	
A.A.A.S. refund for research grants	150.00	
Foundation Fund for research grant	25.00	
Gift designated for payment of editorial work on fifty-year index of Proceedings	250.00	
Sale of Proceedings	12.25	
Author's reprints Vol. No. 48	36.86	
Author's reprints Vol. No. 49	84.08	
		$1,570.15

Disbursements

1—Program Committee	$135.26	
2—Editor (all items of expense)	172.65	
3—Expenses of Secretary	53.35	
4—Expenses of Treasurer	55.00	
5—Mailing Proceedings	19.74	
6—Stationery	44.37	
7—Indianapolis Engraving Co.	168.17	
8—Junior Academy Bulletins	20.00	
9—Surety Bond and Safety Deposit Box	30.50	
10—Research Grant to W. H. Headlee	100.00	
11—Research Grant to J. F. Mackell	50.00	
12—Research Grant to S. S. Visher	25.00	
13—G. H. Smith preparation of index	250.00	
14—Academy Foundation Fund	250.00	
15—Returned checks from members	2.00	
		$1,376.04
Bank balance		194.11
		$1,570.15

(Signed) W. P. MORGAN, *Treasurer,*

(Signed) E. S. MARTIN
(Signed) WM. JOHNSON } *Auditing Committee.*

Junior Academy of Science. Dr. Enders expressed deep regret in the loss by death of the young president, Jack Wilkie, of the Indiana Junior Academy of Science.

It was stated that three new Junior Academy clubs had been admitted during the year and two other applications were now in the hands of the committee. Some adjustments have been made in the status of the Junior Academies during the year; yet thirty-five clubs have been

actively engaged under the direction of the sponsors. It was added that the cooperative relationship with the Illinois Academy of Science and other States in the publication of "Science Aids Service" has contributed much to the interest in the Junior Academy. It was recommended that Academy authorize the usual $20.00 to Mr. Astell, editor, to further this cooperative activity.

The report was accepted and the request that $20.00 to Mr. Astell be given to assist in the publication of "Science Aids Service" was approved.

Relation of Academy to A.A.A.S. It was explained that heretofore the Indiana Academy had received a $150.00 research refund from the A.A.A.S. and, it was believed, that more funds could be made available. It was suggested that an effort be made to interest the membership of the Academy in membership in the A.A.A.S., thus broadening the basis for a research refund from that organization. It was moved and carried that a notice, explaining the advantages of the A.A.A.S., accompany the regular announcements sent to the Academy membership.

Committee for the Preparation of the First Fifty Volume Index of Academy Proceedings. The Executive Committee was informed that the index should be ready for typing by the end of the year and probably available for distribution by the time for mailing the 1941 Proceedings. It was estimated that the index would contain about 350 pages and cost some $1300 for 1500 copies. A discussion followed concerning methods for financing the publication. It was decided that subscriptions from libraries and from the Academy membership would possibly be adequate.

Committee on Nominations. The committee submitted the following recommendations as Fellows of the Academy: Karl Means of Butler University and R. E. Cleland of Indiana University. Recommendations approved.

New Business. The President appointed the Invitations Committee: O. B. Christy, J. J. Davis, and B. H. Smith. The Resolutions Committee was also named: C. M. Palmer, C. A. Malott, and Ray C. Friesner.

Following a discussion on the eligibility for publication of papers in the Proceedings of the Academy, it was moved by Dr. Weatherwax and approved by the Executive Committee that the matter of eligibility for publication in the Proceedings be referred to the Committee on Publication of the Proceedings for study and report.

The subject of the preparation of a classified file of the Academy membership according to the fields of scientific interest was placed before the committee. It was moved that the editor be authorized to secure the necessary information and publish such a list for the Academy membership. Carried.

There was no other business, and the meeting adjourned.

MINUTES OF THE GENERAL SESSION

Friday, November 15, 1940

President L. A. Pittenger of Ball State Teachers College extended a welcome to the Indiana Academy of Science. President Wallace responded in behalf of the Academy. The College Orchestra under the direction of Professor Palmer, entertained with a brief recital.

A brief business session followed. The minutes of the Executive Committee meeting of Thursday evening were read by the Secretary and approved by the Academy.

Will E. Edington presented the necrology for the Academy and spoke briefly of the life work of some eighteen members of the Academy who died during the year.

Glenn A. Black gave an illustrated lecture on "Archaeology at the Angel Mounds Site" and Dr. Yuncker followed with a discussion of the "Life and Customs among the Samoans."

Following the annual banquet, the Membership Committee presented the names of thirty-six applicants for membership in the Academy.

The Nominating Committee submitted the following nominations for officers of the Academy for 1941: *President*, Paul Weatherwax, Indiana University; *Vice-President*, Edward F. Degering, Purdue University; *Secretary*, Winona H. Welch, DePauw University; *Treasurer*, W. P. Morgan, Indiana Central College; *Editor*, P. D. Edwards, Ball State Teachers College; and *Press Secretary*, W. E. Edington, DePauw University. The following were nominated for election as Fellows of the Academy: Karl Means, Butler University, and R. E. Cleland, Indiana University.

The Secretary was instructed to cast a unanimous vote of the Academy for the election of these nominees.

The Divisional Chairman elected in the sectional meetings for 1941 were announced as follows: *Anthropology*, T. B. Noble, Indianapolis; *Bacteriology*, C. G. Culbertson, Indiana University Medical Center; *Botany*, R. E. Cleland, Indiana University; *Chemistry*, J. L. Riebsomer, DePauw University; *Geology and Geography*, Robert Karpinski, Indiana State Teachers College; *Mathematics*, W. E. Edington; DePauw University; *Physics*, R. E. Martin, Hanover College; *Psychology*, Harry N. Fitch, Ball State Teachers College; and *Zoology*, W. E. Martin, DePauw University.

The Academy accepted the invitation of members of DePauw University to hold the annual Fall meeting of the Academy in 1941 at Greencastle, Indiana.

The Resolutions Committee, in behalf of the Academy, expressed sincere appreciation to Ball State Teachers College, its President, Dr. Pittenger, the members of the Science Faculty, and to all others who contributed so generously to the success of the Academy meeting at Muncie.

Following the business meeting, the retiring President, Frank N. Wallace gave a very interesting address on the subject, "Fighting the Japanese Beetle in Indiana."

The 56th annual meeting of the Indiana Academy of Science was then adjourned.

W. P. ALLYN, *Secretary.*

INDIANA JUNIOR ACADEMY OF SCIENCE

Officers for 1940:

President: Jack Wilkie, Elmhurst High School, Fort Wayne (Deceased)

Vice President: Doris Smitha, Geo. Washington High School, Indianapolis

Secretary: Robert Karler, Mishawaka High School

Members of the Council: Anna Inskeep, (1936-1941); Lola Lemon, (1937-1942); J. H. Otto, (1938-1943); P. L. Whitaker, (1939-44) to succeed A. B. Krom, resigned; Roy McKee, (1940-45)

PROGRAM OF THE TENTH ANNUAL MEETING

November 16, 1940
10:00 a. m., Girls' Gymnasium, Burris School
Doris Smitha, Vice-President, presiding

"A New Technique in Gem Cutting," Walter C. Geisler, Shortridge High School.

Papers by Club Members:

1. "The Center of Population—What is it?" Donna Claphan, Geography Council, North Side High School, Fort Wayne, Sponsor, F. J. Breeze.
2. "Construction and Operation of Repulsion Coil," John Southern, Otter Creek Junior Academy of Science, North Terre Haute High School, Sponsor, Prevo L. Whitaker.
3. "The Junior Izaak Walton League," Central Junior Academy, South Bend, Sponsor, A. T. Smith.
4. "Synthetic Flavors," Joseph Eldredge, Central Junior Academy, Chemistry Club, Central High of South Bend, Sponsor, O. C. Osborn.
5. "Building and Flying Gas Model Planes," George Patterson and Leonard Marlow, Physics Club, Arsenal Technical, Indianapolis, Sponsor, E. S. Martin.

1:00 p. m., Auditorium, Burris School

"Astronomy," Dr. L. S. Shively, Ball State Teachers College.

Business session.

Papers by Club Members:

1. "Activities of Our Club," Bill Ingram, Biology Club, Lew Wallace, Gary, Sponsor, Lola Lemon.
2. "Thirty-five Millimeter Slides," Emil Szmid, Central Junior Academy, Photography Club, South Bend.
3. "Chemical Properties of Precious Stones," Max M. Marsh, Chemistry Club, Shortridge High School, Indianapolis, Sponsor, Lois E. Martin.

4. "Microscopic Slide," Jean Ross, Edison Academy of Science, Edison School, Hammond, Sponsor, Max McCowen.
5. "Chemiculture at Home and School," Frances I. Scott, Nature Study Club, Arsenal Technical High School, Indianapolis, Sponsor, Charlotte L. Grant.
6. "School Plants in Kodachrome," Edison Academy of Science, Edison School, Hammond.

Report on progress of the Indiana Junior Academy. Dean Howard E. Enders, Purdue University.

MINUTES

The annual meeting of the Indiana Junior Academy of Science was held in the Girls' Gymnasium of the Burris High School of Ball State Teachers College, Muncie, on November 16.

The members of the Junior Academy stood for a moment in a mark of respect to Jack Wilkie, of the Elmhurst High School, Fort Wayne, who was the President elected one year ago to preside at this meeting; he died in March, 1940. The Vice President, Doris Smitha, of the George Washington High School, Indianapolis, presided.

Dr. H. E. Enders stated the value of the Honorary Membership in the American Association for the Advancement of Science, given to the "Best Girl" and the "Best Boy" of each state. Frances I. Scott of the Nature Study Club, Arsenal Technical High School, Indianapolis and Robert Gericke of the Lew Wallace High School, Gary, were selected by the Council and nominated for these Honorary Memberships.

ROBERT GERICKE
Biology Club
Lew Wallace H. S., Gary

FRANCIS I. SCOTT
Nature Study Club
Technical H. S., Indianapolis

Walter C. Geisler, a lapidary, and member of the Chemistry staff of the Shortridge High School, Indianapolis, presented an interesting demonstration, "A New Technique in Gem Cutting". The five papers by members of Junior Academy Clubs, listed in the program were given. They were well presented and very interesting.

After the noon intermission, Dr. L. S. Shively of Ball State Teachers College, Muncie, gave the principal address on "Astronomy", demonstrated with motion pictures and slides.

Following this portion of the meeting, Council members were chosen. Mr. Prevo L. Whitaker, of the Otter Creek Jr. Academy Club, North Terre Haute, was chosen to succeed Mr. A. B. Krom, resigned, to serve for the unexpired period, 1939-1944. Mr. Roy McKee, Science Club, Gas City, was chosen to serve for the five ensuing years, to succeed F. J. Breeze of the North Side High School, Fort Wayne, whose term expired. The election of officers for the coming year was held. The officers chosen were: *President*, Pat Anderson, Edison High School, Hammond; *Vice President*, Mary Elizabeth Hybarger, Lew Wallace High School, Gary; *Secretary*, Mary Lou Sweet, High School, Marion.

Following the business session the program continued with the presentation of the six papers by club members, as listed in the program. All were well prepared and aroused considerable interest.

Three hundred and fifty Junior Academy members, sponsors and friends attended the meeting.

The meeting adjourned at 3:25 p. m.

DORIS SMITHA, *Vice-President*,
ROBERT KARLER, *Secretary*.

EXHIBITS

The exhibits were installed Saturday morning. Keen interest was manifested by members of the visiting clubs as well as those who demonstrated their own exhibits. The following exhibits were prepared:

1. Geography Council, North Side High Scool, Fort Wayne, F. J. Breeze, Sponsor: Weather maps; collection of fossils.

2. Phy-Chem Club, Elmhurst High School, Fort Wayne, Ruth Wimmer, Sponsor: Soil-less plant growth rosebush; water softening by Zeolite; falling bodies.

3. Nature Study Club, North Side High School, Fort Wayne, Howard H. Michaud and Miss Vesta Thompson, Sponsors: Fossil, rock collection, collection of leaves; club year-books.

4. Nature Study Club, Central High School, Fort Wayne, Iva Spangler, Sponsor: Insulated oven—used for sterilizing, embedding and drying slides and bacteria cultures.

5. Biology Club, Lew Wallace High School, Gary, Lola Lemon, Sponsor: Stamp collection; lizard exhibit case; insect collections; herbaria.

6. Science Club, High School, Gas City, Roy McKee, Sponsor: Terrarium; tree section vs. history on ring records; insects; leaf silhouettes; seeds; fossils; sponges, molluscs; mineral collection; live opossum.

7. Edison Academy of Science, Edison Junior High School, Hammond, Ind., Max McCowen, Sponsor: Leaf collection; terrarium; blue prints of leaves; lantern slides, in black, white and colors.

8. Physics Club, Arsenal Technical High School, Indianapolis, E. S. Martin, Sponsor: Two gas model airplanes.

9. Nature Study Club, Arsenal Technical High School, Indianapolis, Charlotte L. Grant, Sponsor: Plants in chemical solutions; studies in autumn coloration of leaves; insect collections; painting to show "interdependence of plants and animals"; paintings of birds with habitats; fruit collection; bark collection; photographs of nature objects and field trips; map of United States showing state flowers.

10. Chemistry Club, Shortridge High School, Indianapolis, Lois E. Martin, Sponsor: Semi-precious stones; show polish composition; colloidal carbon.

11. Science Club, George Washington High School, Indianapolis, J. H. Otto, Sponsor; Miniature oil field; leaf pigments; voice recording; charts-energy changes; weather charts; physics formulas; food and vitamin charts; crystals from supersaturated solutions.

12. Science Club, High School, Mishawaka, Darl F. Wood, Sponsor: Furs, seeds, medicines; book of state laws; sextant; 3 dimensional graphs of gas laws.

13. Junior Academy of Science, Central High School, South Bend, O. C. Osborne, Sponsor: Apparatus to show how synthetic flavors are made.

14. Camera Club, Junior High School, Sullivan, Ruth Hinkle, Sponsor: Book pictorial history of the year; 30 enlargements of own making.

15. Sciemus Club, High School, Valparaiso, C. O. Pauley, Sponsor: Electric eye; telegraph set; stone and chalk fossils; plaque on photography.

16. Science Club, High School, Wabash, R. D. Black, Sponsor: Exhibit of skulls, fossils and preserved specimens.

17. Science Club, Blaine Jr. High School, Muncie, J. D. Young, Sponsor: Mastodon bones (neck vertebrae, ribs and upper jaw—3 teeth 10" x 6" each).

18. Science Club, High School, Marion, Mrs. Pauline Mayhugh, Sponsor: Demonstrations of chemistry of photograph film; collection of common minerals; chemistry of cosmetics; methylene blue reduction method of milk analysis; lantern slides by students; insect collection; leaf collection; preserved specimens.

19. Biology Club, Crispus Attucks High School, Indianapolis, Mrs. Kuykendall, Sponsor: Photographs; chart showing woods used in national defense; bacteria slides; charts showing Dr. Carver's products made from peanuts and sweet potatoes; photograph of Dr. Carver.

20. Otter Creek Junior Academy of Science, North Terre Haute, Prevo L. Whitaker, Sponsor: Micro-projector and slides; insect collection; Metamorphois of the silk worm; leaf collection.

INDIANA JUNIOR ACADEMY CLUBS

Anderson	Science	1936	M. J. Brosier
*Bloomington	General Science, Junior H. S.	1931	M. M. Williams
	University School Science Club	1938	W. B. Miner
Cambridge City	Tri Science	1934	J. L. Bozarth
*Crawfordsville	Audubon Society, Junior H. S.	1931	Emmet Stout
East Chicago	Edison Club, Roosevelt H. S.	1935	Harry Apostle
Fort Wayne	*Geography Council (North Side H. S.)	1932	F. J. Breeze
	Nature Club (North Side H. S.)	1936	H. H. Michaud Vesta Thompson
	Phi-Chem Club	1937	H. A. Thomas
	Phy-Chem Club, Elmhurst H. S.	1935	Ruth Wimmer
Gary	Biology Club, Lew Wallace H. S.	1935	Lola Lemon
Gas City	Science	1936	Roy McKee
Greencastle	Science	1936	F. N. Jones
Guilford	Science	1936	L. B. Willis
Hammond	Edison Academy of Science		Max McCowen
Indianapolis	*Crispus Attucks H. S. (Biology, Chemistry, Zoology, Radio)	1931	C. E. Ransom, Mrs. Kuykendall, A. C. Cox, G. W. Wade, and L. C. Parker
	*Technical Schools—Nature Study	1932	Charlotte Grant
	*Shortridge—Chemistry Club	1931	Lois Martin
	George Washington H. S., Science Club	1937	J. H. Otto
Lafayette	Jefferson High School—Biology	1939	Kenneth Dobelbower
Lawrenceburg	Phi-Bi-Chem	1939	H. P. Harrison
Lowell	Science	1935	C. N. Seeright
Madison	Science	1938	Evans Cottman
Marion	Science	1936	Pauline Mayhugh
Mishawaka	Science	1936	Darl F. Wood
Montmorenci	Junior Academy of Science	1933	I. W. Vance
Mooresville	Science	1936	Fitzhugh Lee
Muncie	Science, Blaine Junior H. S.	1934	J. D. Young
New Albany	Junior Academy (Junior H. S.)	1935	Gladys Knott
North Madison	*Hilltop Nature Study Club	1931	V. Shoemaker
North Terre Haute	Otter Creek Junior Academy Science	1939	Prevo L. Whitaker
Paoli	Science	1935	O. R. Whitlock
South Bend	Science, Central High School	1939	O. C. Osborn
Terre Haute	Junior Science Club (Laboratory School)	1939	Geraldine Shontz
	State High Discovery Club, Senior H. S., Laboratory School	1939	V. C. O'Leary
Tipton	Natural Science Club		W. D. Hiatt
*Valparaiso	Sciemus	1931	C. O. Pauley
Wabash	Science	1936	R. D. Black
West Lafayette	Biology Senior High School	1933	Anna Inskeep

* Charter clubs.

NEW CLUBS IN 1940 AND DIVISIONS OF OLD CLUBS

Elkhart	Biology Club	N. E. Adams
Sullivan	Camera Club	Ruth Hinkle
Fort Wayne	Nature Club, Central H. S.	Iva Spangler
South Bend	Divisions of Central High School in addition to Science Club	
	Junior Izaak Walton Club	Arthur L. Smith
	Natural Science Club	C. C. Miller
	Photography Club	W. W. Lauterback
	Radio Club	Claude Bush
	Camera Club I	Elmer Barnbrook
	Camera Club II	Rose M. Gillespie
Fort Wayne	Elmhurst H. S. Physics Club	M. Logan
Indianapolis	Technical H. S. Physics Club	Ersie Martin

NECROLOGY

WILLIS STANLEY BLATCHLEY

North Madison, Connecticut — Indianapolis, Indiana
October 6, 1859 — May 28, 1940

Willis S. Blatchley, one of Indiana's really great scientists, passed away May 28, 1940, bringing to a close a lifetime of eighty years devoted to science and nature study. Born of humble parentage he was brought to Indiana as an infant and spent his boyhood in Putnam county where he received his early education with his father as one of his first teachers. In early manhood he peddled notions, sold maps and took orders for picture enlargements in order to get funds that enabled him to attend

several six weeks sessions of normal schools. After teaching several years, and after being married to Miss Clara A. Fordice in 1882, he entered Indiana University in 1883 and came under the powerful influence of David Starr Jordan and John C. Branner. Under the guidance of these two great scientists Dr. Blatchley discovered and entered upon his life's real work, for he published nine research papers before his graduation in 1887.

Following his graduation he became head of the Department of Science in Terre Haute High School where he remained until his election as State Geologist in 1894. During this period of time, however, he assisted Dr. Branner in the state geological survey of Arkansas, went to

Mexico as a member of the Scovell Expedition to determine the height and natural history features of Mt. Orizaba, and later served as an assistant on the U. S. Fish Commission collecting fishes in Indiana and Ohio. He also received his Master's degree from Indiana University in 1891.

Dr. Blatchley served as State Geologist for sixteen years during which time he not only carried on the duties of his office most effectively but also published besides his annual State Geological Reports twenty-seven research papers and books. Following his defeat in 1910 for his fifth term as State Geologist, he and Mrs. Blatchley spent the winter in Florida, and in 1913 he began regularly making his winter home in Dunedin, Florida, which he continued to the end of his life. Also he carried on his researches in both Florida and Indiana and made scientific trips to Alaska and Canada in 1913, and to South America in the winter of 1922-23. He published his "Rynchophora or Weevils of Northeastern America" in 1916, "Orthoptera of Northeastern America" in 1920, and "Heteroptera or True Bugs of Eastern North America" in 1926, all authoritative works which secured for him national standing as an entomologist. On account of his work Indiana University honored him in 1921 with the LL.D degree.

Dr. Blatchley was the author of over 200 scientific articles and books. He gave many lectures before scientific bodies in various parts of the United States. Known and recognized as Indiana's greatest naturalist, he also had a poet's love for and insight into the mysteries of nature, and he lived and taught a philosophy gleaned from his geological, botanical and zoological researches, which was expressed in his books "Gleanings from Nature," "Boulder Reveries," "Woodland Idylls," and others. He discovered and named a number of new genera and subgenera of Coleoptera and Heteroptera, and classified many others.

In the Indiana Academy of Science Dr. Blatchley was recognized as one of the charter members and was made a Fellow in 1893 and later an Honorary Fellow. He served as its president in 1903, and throughout his life took an active part in its work, giving his last address before the Academy shortly after his eightieth birthday at the winter meeting in November, 1939, in Terre Haute. He was also an honorary fellow in the Entomological Society. He also had the unique honor of being the patron saint of a natural history club, known as the W. S. Blatchley Club, with headquarters in Noblesville. This club honored his memory with a memorial service on his eighty-first birthday.

Some years ago Dr. Blatchley wrote "There are, in my opinion, too many specialists and too few naturalists in the world today. What is a naturalist? On whom should the title be rightfully bestowed? That question can most easily be answered by naming some of the naturalists of the past and present. Linnaeus, Darwin, Huxley, Agassiz, Say, Nuttall, Rafinesque, Audubon, Thoreau, Leconte, Baird, Cope, Jordan, Evermann—they were all great naturalists of the world at large." To this list the name Blatchley may now be added. Certainly he will rank with Jordan, Evermann, Eigenmann, Butler, John M. Coulter, Wiley and the other great scientists who were members of the Indiana Academy of Science.

CHARLES J. BUCHANAN

Marion County, Indiana — Indianapolis, Indiana
August 31, 1856 — September 14, 1938

Charles J. Buchanan was one of those rare, outstanding business men with a deep interest in science. However, his whole life was characterized by a comprehensive outlook that made him a leader in many fields of endeavor. Derived from Mayflower and Revolutionary stock he possessed that rare charm, courtesy and gentility that endeared him to his community and enabled him to be a leader in his profession.

Mr. Buchanan was born on a farm in Marion county and attended the county schools and Valparaiso University. After teaching for a short time he entered the funeral business in 1887 with his brother-in-law Frank W. Flanner under the name of Flanner and Buchanan. He was early interested in cremation and later became president of the Cremation Association of America.

President of his company from 1912 until his death, and nationally prominent in his profession, he realized his opportunities for service and became a civic and philanthropic leader in Indianapolis. The church, the Y. M. C. A., the Indianapolis Home for Aged Women, and other welfare projects received his active personal and generous financial support. Throughout his long life he was always interested in promoting the educational, religious and moral welfare of the community.

A moving spirit in the Society of Indiana Pioneers, he was zealous in his support of progressive legislation and was a member of the State Legislature several terms. He was active in church work, and at the time of his death was one of the oldest members and a trustee of the First Congregational Church of Indianapolis. He was also prominent in Masonry.

Mr. Buchanan's interest in science was that of a naturalist, and he early became a member of the Nature Study Club. He was its song leader for many years and was also its president at one time. Although he was not active in the affairs of the Indiana Academy of Science. nevertheless the interest and support of a man of his business and civic prestige was most valuable and his loss will be keenly felt.

BENJAMIN WALLACE DOUGLASS

Indianapolis, Indiana — Trevlac, Indiana
February 17, 1882 — December 6, 1939

Probably not since the time of Maurice Thompson has the Indiana Academy of Science had a member possessing the literary prominence of Benjamin Wallace Douglass. Author of more than four hundred magazine articles, besides several books, and a contributor to such magazines as the *Country Gentleman, Saturday Evening Post, Collier's*, and *Better Homes and Gardens*, Mr. Douglass nevertheless remained always the scientist at heart.

Born of well-to-do parents, his father being one of the founders of the Douglass and Carlton Printing House, later the Hollenbeck Press, Mr. Douglass was educated in the Indianapolis public schools, graduated

from Shortridge high school, and then attended the Central College of Physicians and Surgeons, but he did not complete the medical course.

In 1904 he became field agent for the State Board of Forestry and in 1907 he organized the state entomologist's office and became Indiana's first State Entomologist. Resigning after four years of service he devoted the rest of his life to fruit growing, agriculture and literary work. He established an orchard on Hickory Hill, near Trevlac, in Brown county, and later founded the Hickory Hill Farmstead Community, where the products of his orchards and farm and those of his neighbors were prepared for market. He was an earnest advocate of conservation. In 1917 his nature book "Orchard and Garden" appeared, to be followed by "Fruit Growing" in 1920, and "Beekeeping" in 1921. Later he became interested in politics and in 1936 published his book "The New Deal Comes to Brown County." Shortly before his death he was working on a book "dealing with Indiana and Hoosiers and how they get that way," as he expressed it. Possessing a keen sense of humor, and real ability as a speaker, he made many addresses during his last years.

Mr. Douglass was active at different times in the Academy, occasionally giving illustrated lectures. His last appearance before the Academy was in 1930 when he gave an illustrated lecture on "Brown County Culture" at the spring meeting. In the passing of Benjamin Wallace Douglass the Academy loses a distinguished member and the State of Indiana a loyal and widely known citizen.

SISTER M. FLORENTINE (MARY THERESA DALY)

Philo, Illinois	Notre Dame, Indiana
April 13, 1890	April 9, 1939

With the death of Sister M. Florentine a life of service to the church and science was brought to a close. Sister Florentine received her early education in St. Joseph's School, in Philo, Illinois, and entered Saint Mary's College, Notre Dame, in 1914, graduating in 1918. Taking the Habit of the Sisters of the Holy Cross in 1918 at Saint Mary's, she made her perpetual vows in 1923. Although she majored in English and minored in chemistry in her college course, her love for science asserted itself and she pursued graduate courses in chemistry and mathematics at Notre Dame University, receiving the Master's degree in 1924 and the Ph. D. in 1931.

She began teaching at Saint Mary's College in 1920 and at the time of her death she was professor of chemistry and head of the Department of Science. Possessing a keen insight into the problems of youth and enjoying the confidence of her students on account of her sincerity and sympathetic understanding, she rendered a real service to the college through her work as faculty representative on the student council. However, her principal interest was in chemistry and her standing was such as to secure her the vice-chairmanship of the St. Joseph Valley section of the American Chemical Society in 1938. She also held membership in the American Association for the Advancement of Science. Her death brought a distinct loss to science teaching in the State.

ULYSSES SHERMAN HANNA

Selma, Indiana — Bloomington, Indiana
January 16, 1865 — February 18, 1940

Ulysses Sherman Hanna was one of that large group of men whose lives are indissolubly associated with the history of Indiana University, whose service began in the last century and continued more than forty years. After his graduation from Muncie, Indiana, high school, he taught in Newcastle high school for four years and then entered Indiana University and received the A.B. and A.M. degrees from that institution. Appointed to an instructorship in the Department of Mathematics in 1895 he remained at Indiana University until his retirement in 1936 as emeritus professor, with the exception of two years spent as Harrison Fellow at the University of Pennsylvania where he later received the Ph.D. degree.

Professor Hanna took an active interest in the civic, church and fraternal affairs of Bloomington and during his 46 years of residence there he held many city positions. "He was secretary and then president of the Bloomington Water Company, president of the City Park Board, a director of the Chamber of Commerce, a member of the City Council, president of the Workingman's Building and Loan Association, city engineer and county engineer and surveyor." He was a trustee of the First Methodist Church. In fraternal affairs he was a member of the Odd Fellows, Elks, Knights of Pythias, Bloomington Kiwanis Club, and the Indiana University Faculty Club. A thirty-second degree Mason, Shriner and Knights Templar, he was president of the Masonic Temple Association.

In educational affairs he was also active, holding membership in Phi Beta Kappa, Sigma Xi, Acacia, the American Mathematical Society, the Mathematical Association of America, and several foreign societies.

Professor Hanna was primarily a teacher, and as such he endeared himself to several generations of Indiana University students. To his colleagues and the citizens of Bloomington he was not only a teacher but a man of excellent business ability and sterling integrity with a keen sense of civic duty.

ALLEN DAVID HOLE

Bridgeport, Indiana — Philadelphia, Pennsylvania
August 6, 1866 — August 22, 1940

To few men has been given the privilege and responsibility of influencing not only their own age but also future generations. Especially is this true in science, but such a scientist was Agassiz, and Indiana science is particularly indebted to him for his influence on David Starr Jordan and Joseph Moore. All members of the Academy are aware of the prestige of Jordan, but Moore's life is not so well known except to Earlham graduates and the older Indiana scientists. Moore was an excellent scientist, a great teacher and a wise man who inspired his students. Allen David Hole was a student under Moore and like his great teacher he has left his impress upon his students.

Allen David Hole graduated from Earlham College in 1897 and then taught several years in the elementary schools before joining the faculty at Earlham in 1900 as an instructor of mathematics. His chief interest, however, was in geology, and after receiving the Master's degree from Earlham in 1901, he was prepared to take complete charge of the geology work after Joseph Moore's death in 1905, and to develop that department into one of the strongest in the college. As evidence of his great influence it is said that one tenth of those in soil survey work for the United States are former students of Dr. Hole. In 1910 he received the Ph.D. degree from the University of Chicago. From 1918 to 1924 he served as vice-president of Earlham.

Dr. Hole was a firm believer in practical science and was active in geological work outside the college. From 1906 to 1916 he was a member of the United States Geological Survey working during the summers in the mountains of Colorado, and for a number of years he was associated with the Indiana Geological Survey mapping soils and making examinations for moulding sand. Many of his students were his assistants in this work. For many years he conducted summer geological expeditions of students to Yellowstone Park, Glacier Park, the Grand Canyon and other western localities of geological interest. In 1905 he was appointed curator of the Joseph Moore Museum at Earlham and through the years he was ever alert to secure new specimens for the improvement of the museum.

A deeply religious man, he was a recorded minister of the Society of Friends. For fifteen years, from 1912 to 1927, he was chairman of the Peace Association of the Friends in America and was editor of its periodical, *The Messenger of Peace.* Likewise for fifteen years he was chairman of the Executive Committee of the Five Years Meeting and exerted great influence in shaping the program of this combined group of Friends and associates in America. Without doubt he was one of the outstanding Friends in this country.

Dr. Hole was honored by Earlham with the LL.D. degree in 1937. In 1931 he received the Earlham Faculty Recognition award of $100 for distinguished service as a great teacher. He was a Fellow in both the American Association for the Advancement of Science and the American Geographical Society, and in 1931 he was elected a Fellow of the Indiana Academy of Science.

Earlham College held a memorial service in honor of Dr. Hole on September 22, 1940.

With the death of Allen D. Hole education and science in Indiana have lost an outstanding and inspiring teacher and the Academy has lost another distinguished member.

EDWIN MORRISON

Bloomingdale, Indiana — East Lansing, Michigan
March 5, 1861 — July 16, 1939

Professor Edwin Morrison was born at Bloomingdale, Indiana, of Quaker parentage and his early education was received at the Bloomingdale Academy. He attended Earlham College from which he graduated

in 1888, and three years later he received the M. S. degree from Indiana University with physics as his major field of interest. He later did considerable graduate study at the University of Chicago.

Following the completion of his work at Indiana University he became Professor of Science at Pacific College, Newberg, Oregon, and remained there ten years. He then accepted a similar position at Penn College, Oskaloosa, Iowa, and in 1906 returned to Earlham as head of the Department of Physics. In 1919 he went to Michigan State College as professor of physics where he remained until his death.

Professor Morrison was a strong believer in the use of the laboratory as a means of teaching physics, and he strove constantly to improve his laboratory so that his students might have a practical working knowledge of physics.

Although a non-resident of Indiana for many years Professor Morrison retained his interest in the Indiana Academy of Science of which he was a Fellow. He was also a member of the American Association for the Advancement of Science, the American Physical Society, the American Association of Physics Teachers, and the American Optical Society.

DAVID MYERS MOTTIER

Patriot, Indiana	Indianapolis, Indiana
September 4, 1864	March 25, 1940

If one were seeking the one thing that characterized the policy of Indiana University in the last decade of the last century that has left the greatest impress upon the University it would be the appointment of the large number of alumni to faculty positions who remained with the University the remainder of their lives. Ordinarily this would not be a good policy, but so inspiring and great was the influence of David Starr Jordan and so keen was Joseph Swain's insight into the ability of men that Indiana University became outstanding among American universities. David Myers Mottier was one of those appointees of the last century.

Dr. Mottier graduated from Indiana University in 1891, was immediately appointed an instructor in botany and completed the work for the Master's degree the following year. He became an associate professor in 1893, but soon went abroad and obtained the Ph.D. degree at the University of Bonn in 1897. He also studied at the University of Leipzig, and was a Smithsonian Research Student at the Naples Biological Station in 1898. He was made a full professor and head of the Department of Botany in 1898 which he remained until his retirement in 1937 as emeritus professor of botany. Professor Mottier's active association with Indiana University covered a period of fifty years.

Dr. Mottier was recognized as an authority in botany with an international reputation, his name being starred in American Men of Science. He was the author of many scientific papers and three books: "Practical Guide Laboratory for First Year in Botany," published in 1902; "Fecundation in Plants," in 1904; and "College Textbook of Botany," in 1932. He presented papers before national scientific societies, and was very active

in the affairs of the Indiana Academy of Science, of which he was a charter member, a Fellow, and its president in 1907.

He was a life member of the Botanical Society of America, a Fellow of the American Association for the Advancement of Science, and a member of the Washington Academy of Sciences, the Botanists of Central States, the American Society of Naturalists, Phi Beta Kappa and Sigma Xi.

Dr. Mottier possessed that spark that characterized most men whose careers were influenced by David Starr Jordan, and he in turn inspired those who worked under him. Affable and charming in personality he was a man of firm convictions. He was ever sympathetic with the struggling student for he was an excellent teacher.

Early Indiana science and the early history of the Indiana Academy of Science are noteworthy because of the large number of men who attained national and international prominence as scientists. With the widespread development of science in the United States such a concentration of scientific leadership again in Indiana is very improbable. Accordingly the loss of Dr. Mottier to the Academy and to the State will be long and keenly felt.

WENDELL LEROY PERKINS

Nashville, Michigan	Terre Haute, Indiana
October 5, 1887	January 13, 1940

Wendell Leroy Perkins was born in Nashville, Michigan, and spent his youth there. After graduating from Nashville high school he attended the University of Michigan where he graduated in 1911 and received

the Master's degree in 1919 with geology as his major subject. He was a teaching assistant in geology under Professor William H. Hobbs for one year at the University of Michigan. Later he did considerable graduate study at the University of Chicago and had about completed his thesis for the Ph.D. degree at the time of his death.

He began his teaching career as a science teacher in the Jackson, Michigan, high school, but after one year he went to Dowagiac, Michigan, as principal of that high school. In 1915 he became principal of the high school at Bay City, Michigan, and later dean of the newly organized junior college in that city. He was called to the Indiana State Teachers College in 1924 as assistant professor of geography and geology where he remained until his death.

Professor Perkins was an able and inspiring teacher with considerable executive ability. He was enthusiastic in his teaching work and particularly interested in travel trips. He had conducted several tours to various parts of the United States and Canada, and he spent the summer of 1929 in Mexico.

While primarily interested in teaching, Professor Perkins had published several research papers and was a member of Sigma Xi. He was much interested in the work of the Academy and had appeared on several of its programs. With his death the Academy has lost a valuable member and science an excellent teacher.

EDWARD JACOB PETRY

Gnadenhutten, Ohio	Cedar Rapids, Iowa
June 24, 1880	October 8, 1939

Edward Jacob Petry, a native of Ohio, graduated from Ohio State University in 1907, and then went to Cornell University as an assistant in botany. A few years later he came to Purdue University as an instructor in agronomy and in 1916 he was promoted to an assistant professorship in agricultural botany. He went to the University of Michigan as an instructor in 1918 and two years later became professor and head of the Department of Botany at South Dakota State College. For several years he was a consulting botanist and also was connected with the South Dakota Geological and Biological Survey. In 1926 he accepted the headship of the Department of Biology at Hendrix College, later transferring to Center College and then to Coe College in 1931 as professor of botany, where he remained until his death.

Professor Petry received the Ph.D. degree from Michigan State College in 1925. He was the author of a number of research papers. His association with the Indiana Academy of Science began when he was an instructor at Purdue, but after leaving Indiana he became a member of the South Dakota and Iowa Academies of Science, and he was active in their work. A fuller statement of his life and work will appear in the 1940 Proceedings of the Iowa Academy. Professor Petry was also a member of the American Association for the Advancement of Science, the Society of Plant Physiologists, Genetics Association, Eugenics Society, and several others.

FERMEN LAYTON PICKETT

Bakers Corner, Indiana — Pullman, Washington
January 10, 1881 — June 27, 1940

Fermen Layton Pickett was born in Indiana and received all his formal education in Indiana. Showing unusual promise in botany he was made an instructor in botany immediately after his graduation from Indiana University in 1910. He also served as a critic teacher of botany in his senior year and for three years after his graduation. Receiving his Master's degree in 1912 and serving as a Fellow in 1913-1914, he received the Ph.D. degree in 1915, a year after he had been called to the State College of Washington as associate professor of botany. Here he remained for the rest of his life for he was made professor and head of the Department of Botany in 1918 and Dean of the Graduate School in 1930.

Dr. Pickett was one of the many students whose careers were greatly influenced by Dr. Mottier. His principal scientific interest was in morphology and ecology and he wrote a number of scientific papers several of which were on Indiana mosses. He maintained a deep interest in these fields although his teaching and executive duties required most of his time. Quiet and somewhat retiring he nevertheless had strong convictions. He was active in church work and at one time taught the largest bible class for men in Pullman.

He was a member of the American Association for the Advancement of Science, the Botanical Society, the Ecological Society, Fern Society, Sullivant Moss Society, and the Western Society of Naturalists. He had maintained his membership in the Indiana Academy of Science throughout the twenty-five years that he resided in Washington.

A highly respected citizen, an able executive, and a prominent scientist and educator in the West, his loss will be keenly felt.

JAMES HARVEY RANSOM

Chazy, New York — Decatur, Illinois
September 21, 1861 — May 31, 1940

The history of a State Academy of Science is largely the history of the men who have been active in its work, and its influence and greatness are proportional to the influence and greatness of these men. And an Academy is honored the more by having outstanding men who have long since left the State maintain their interest in its work. Such a man was James Harvey Ransom.

Born in New York but moving with his family to Minnesota as a small child, Dr. Ransom attended the public schools of Albert Lea, Minnesota. He entered Wabash College and after graduating in 1890 remained there as an assistant in chemistry until he received the Master's degree in 1893. He then taught chemistry and physiology in the Chicago Training College for four years. Accepting an assistantship in the University of Chicago he received the Ph.D. degree in 1899 but remained another year before going to Purdue University where he taught for

eighteen years, being professor of general chemistry for the last ten years. During his tenure at Purdue he attended the Seventh International Congress of Chemistry in London in 1909.

In 1918 he became professor and head of the Department of Chemistry at Vanderbilt University but resigned the following year to become research director of the Michigan Smelting & Refining Company in Detroit. Two years later he was appointed head of the Department of Chemistry at the James Millikin University where he remained until his death.

Dr. Ransom was the author of a number of research papers in chemistry. He also wrote four books: "Experimental General Chemistry" in 1911, revised and enlarged in 1912; "General Chemistry" in 1914; "Outline of Qualitative Analysis" in 1922; and "Experimental Chemistry, General and Qualitative" in 1928.

He was a Fellow of the American Association for the Advancement of Science, and a member of the American Chemical Society, the American Institute of Chemical Engineers, the Institute of Metals (London), and the Illinois Academy of Science. A Fellow of the Indiana Academy of Science he was assistant secretary from 1903 to 1907 and secretary the next two years.

Dr. Ransom was prominent in church affairs in Decatur, being an elder in the First Presbyterian Church and at one time secretary and later superintendent of the church school. He was an able and inspiring teacher. Dr. John C. Hessler, president of the James Millikin University, paid high tribute to Dr. Ransom and wrote "His standards were high and he reacted vigorously against any attempt to lower them. He was, withal, a sincere Christian and a very lovable gentleman."

HARRY BENJAMIN THOMAS

Everett, Pennsylvania	Indianapolis, Indiana
November 14, 1885	March 10, 1940

Harry Benjamin Thomas, a successful physician and respected citizen of Bloomington, passed away in an Indianapolis hospital following an operation. Born in Pennsylvania his early education was received in a rural school and a Normal school. He began teaching at the age of sixteen, and after teaching several years, he entered Valparaiso University where he received his pharmaceutical degree in 1912. From 1912 to 1923 he worked in Gary, first as a steel mill chemist and later as manager of a drug store. During the World War he served as a chemist with the Aetna Explosives Company near Gary. In 1923 he entered the Indiana University Medical School and after receiving the M.D. degree and completing his interneship, began practice in Bloomington. Recognized as one of the leading physicians of the community, he served as part time instructor of anatomy in the Indiana University Medical School.

Dr. Thomas was a member of the Lutheran Reformed Church, the Bloomington Kiwanis Club, the Bloomington Chamber of Commerce,

and the Phi Chi medical fraternity. He was one of the too few practicing physicians associated with the Academy and his loss is deeply regretted.

WILLIAM PAYSON TURNER

Isle au Haut, Maine — Lafayette, Indiana
August 2, 1867 — April 28, 1940

Few men have had the privilege and distinction of serving a great university for more than a half century, but with the death of William Payson Turner Purdue University lost not only one of its best known professors but the one who in serving the institution fifty-two years before his retirement in 1938 had served it longest. Known as the "Deacon" to thousands of Purdue engineers who came under his guidance in machine shop instruction and to other thousands of graduates who knew him as the University Marshal in charge of academic processions, Professor Turner's period of service, begun in 1886, was contemporary with the growth of the engineering schools at Purdue.

Professor Turner attended the Massachusetts Institute of Technology from 1884 to 1886 and then as a youth of nineteen came to Purdue to take charge of the shops to be established under the general direction of Professor Michael Golden. An excellent and inspiring teacher and a fine organizer, he placed machine shop instruction on a high level. He wrote several papers describing machine shop methods and work which were presented before the Society for the Promotion of Engineering Education and the American Society for Testing Materials. He was also the author of a textbook on Machine Tool Work, and he designed the Purdue Impact Machine.

Professor Turner was a member of the American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education. While long a member of the Indiana Academy of Science he had not been active in its work as the Academy had no engineering section. Nevertheless his interest in and support of the Academy was valuable for its influence on others.

FRANCIS JOSEPH WENNINGER

Pamhagen, Austria — Notre Dame, Indiana
October 27, 1888 — February 12, 1940

Indiana scientists were shocked at the sudden and untimely passing of Father Francis J. Wenninger, C.S.C., Dean of the College of Science and Head of the Department of Biology at Notre Dame University. Born in 1888 in Austria he came as a youth with his parents to South Bend where he received his early education and spent most of the rest of his life. Entering the Seminary of the Congregation of Holy Cross in 1903, he received the Litt. B. degree at Notre Dame in 1911 and was ordained in 1916, after receiving the S.T.B. degree from Catholic University of America in Washington, D.C. He received the M.S. degree from Notre Dame in 1917 and the Ph.D. from the University of Vienna

in 1928 with zoology (parasitology) as his major subject and anthropology as his minor interest.

Father Wenninger was a great teacher and an excellent administrator. Dean of the College of Science since 1923 much of the development of the College of Science at Notre Dame is due to his efforts. He was a man of broad interests, and for many years coached the Notre Dame debating team. He frequently lectured on scientific and religious topics. Author of a number of papers on protozoology, entomology, malacology, and parasitology, he was also associate editor of the *American Midland Naturalist.* As both a churchman and a scientist his influence was doubly great on his students who found him a wise counsellor and an understanding friend.

Father Wenninger was a member of the American Association for the Advancement of Science and a Fellow in the Indiana Academy of Science. He was deeply interested in the work of the Indiana Academy and after the death of Father Nieuwland he had done much to maintain the interest of the scientists at Notre Dame in the Academy. With the death of Father Wenninger the Academy has suffered a real loss.

RICHARD B. WETHERILL

Lafayette, Indiana	Lafayette, Indiana
January 10, 1859	March 27, 1940

World traveler, historian, philanthropist, and retired physician and surgeon, Richard B. Wetherill passed away after a long life of service and scientific study. Born of Quaker ancestry who came from England to America in 1682, he was the son of Charles M. Wetherill appointed by Abraham Lincoln as the U. S. Department of Agriculture's first chemist. Dr. Wetherill received his early education in the Lafayette schools, attended Purdue University one year, Lehigh University four years, and then in 1883 graduated from Jefferson Medical College in Philadelphia. Following that he studied in Berlin and Vienna, being at one time under Robert Koch, and on his return to the United States he took post graduate work at the University of Pennsylvania. He began practicing in 1886 in Lafayette and became one of the leading surgeons in that section of the State. He retired in 1917 to enter the Volunteer Medical Corps and served at Purdue until 1919. Purdue conferred the LL.D. degree upon him in 1936.

Following his retirement most of his time was devoted to the study of ancient civilizations, and the founding and promotion of the Tippecanoe County Historical Association. In his world travels he made a trip from Cairo across Africa to Cape Town, and he was one of the first to be permitted to look into the tomb of Tutankhamen in Egypt after it had been opened and before anything had been removed. He had also made trips to Indo-China, Mesopotamia, Egypt, Yucatan, Mexico, and Peru. He brought back many objects of scientific and historical interest.

Dr. Wetherill was a member of the county, State and American Medical societies, and a Fellow of the College of Surgeons. He was a

member of the Pathological Society of Philadelphia and the American Oriental Society. As one of the founders and for fifteen years the head of the Tippecanoe County Historical Association he made that organization the beneficiary of a large trust fund as well as the recipient of his art treasures and curios. Purdue University also received a bequest of $25,000 as a scholarship fund.

Dr. Wetherill was a vice-president of the Indiana Historical Society and his latest publication appeared in the *Indiana Magazine of History* in 1939. As a member of the Indiana Academy of Science his interest was in archaeology and anthropology. With his death the Academy and the State lose an enthusiastic scientist and an outstanding citizen.

JACK WARD WILKIE

Cleveland, Ohio	Fort Wayne, Indiana
April, 1923	March 20, 1940

It is with the keenest regret that one records the death of Jack Ward Wilkie, president of the Indiana Junior Academy of Science. Born in Cleveland, Ohio, he came with his parents to Fort Wayne as a small child, and after finishing the grade schools entered Elmhurst High School of that city to prepare for college. An excellent student, generally on the Honor Roll, he became interested in chemistry which led to his affiliation with the Junior Academy. He attended the meeting of the Junior Academy in November, 1939, at Terre Haute, and was elected president of the Junior Academy for 1940. He accepted this honor seriously and conscientiously, and immediately set about preparing a chemically fed rose bush as his exhibit for the 1940 meeting. A fine student, an excellent debater, popular with his fellows, his sudden and unexpected death came as a distinct shock.

As evidence of their regard for him his friends have presented a memorial debating plaque to Elmhurst High School on which will be engraved each year the name of the outstanding debater of the school for that year. Also his Presbyterian Sunday school class has presented the church a large American flag in honor of him. While young in science, he nevertheless showed considerable promise, which together with his qualities of leadership, makes his passing the more deplorable.

CHARLES ZELENY

Hutchinson, Minnesota	Urbana, Illinois
September 17, 1878	December 21, 1939

Charles Zeleny, one of the leading zoologists in the United States at the time of his death, was one of four brothers, all outstanding in their respective fields. A native of Minnesota, he entered the University of Minnesota and graduated in 1898, but continued there with graduate study until he received the M.S. degree in 1901. He spent the next year in study at Columbia University under T. H. Morgan and E. B. Wilson and then went to the Naples Biological Station for a year. Upon his return

to the United States he entered the University of Chicago where he received the Ph.D. degree in 1904. Coming to Indiana University as an instructor in zoology he received rapid promotion and was associate professor at the time of his resignation in 1909 to accept a position at the University of Illinois. It was while he was at Indiana University that he became a member of the Indiana Academy of Science. His ability was recognized at the University of Illinois, for he was head of the Department of Zoology and chairman of the Division of Biological Sciences at the time of his death.

Dr. Zeleny was vice-president of the Zoology Section of the American Association for the Advancement of Science in 1932 and president of the Society of Zoologists in 1933. He was a member of the Society of Naturalists, the Genetics Society, the Eugenics Society, the Eugenics Research Association, the Institute of Anthropology, and several foreign societies. He had done outstanding research in the fields of regeneration, experimental embryology and genetics and he was the author of a large number of scientific papers.

Somewhat quiet and reserved in manner, he nevertheless was a stimulating and effective teacher. He was interested in the Indiana Academy of Science and occasionally attended its meetings, being present the last time at the semi-centennial meeting several years ago. With his death science suffers a distinct loss.

PRESIDENTIAL ADDRESS

Japanese Beetle Control in Indiana

FRANK N. WALLACE, Conservation Department

It has been the custom of the President of the Indiana Academy of Science to spend an assigned portion of time on the reading of a paper, which is devoted to some particular phase of knowledge he has gained through the medium of observation or study. During the past 25 years it has been my good fortune to serve as chief of one of the offices of the state government, I have had an opportunity to serve—and I hope to learn—something about the intricate workings of a state office, and in the meantime, have become acquainted with the general public's reactions to such an office and to the person in charge.

The subject of my talk is the Japanese Beetle. I shall try, in some detail, to show what success we have had in the past seven years in controlling this pest, which is considered one of the worst with which America has had to contend. I shall also touch briefly upon the campaign against the European corn borer of some twelve years ago, which was not a success. I hope that it may be possible for me to bring out what I consider the basic reasons for the success of one project and the failure of the other.

Suppose we dispose of the European corn borer first, because I fear it will not be disposed of in any other way.

A campaign of eradication was started against the European corn borer by the federal government in 1927 and the war correspondents never received such glaring headlines as the copy desks of the papers used on the stories about the European corn borer. Day after day the battle raged and the farmers were called upon for new efforts in the fight against this invader. We were almost successful in our cleanup campaign in Indiana, but when it became apparent to the farmers that this was a battle of an army of more leaders than there were worms, they refused to battle the worms. But by this time they were trained fighters and they turned on their leaders. If we could have kept them after the corn borer with the same enthusiasm that they expended on us, the corn borer problem might have been solved. I believed then, and still believe that the over-emphasized publicity on the corn borer at that time was largely responsible for the unsatisfactory results of this program.

During the third year of the European corn borer control work the farmers of Indiana demanded that the federal government cease their eradication program. At that time the corn borer had been almost exterminated. Complete extermination might not have been entirely possible, but the federal restrictions would have kept it under control to a point that it could not have caused much injury.

Our survey of European corn borer in 1940 reveals the fact that it is present in sufficient numbers to cause marked damage in several

counties. The heaviest infestation was found in Wells County; the average number in that county is three and one-third borers per stalk. Allen, Adams, Blackford and Jay counties show more than two borers per stalk, and from this on down our survey reveals less than two-tenths of a per cent per stalk in some of the counties that were surveyed this summer. Should we have a season favorable to the increase of borers next year, we will have many farmers in the five heaviest infested counties with 25 to 50 per cent injury to their corn crop.

The public, always interested in the function of its government, expects to be told what is being done in a state public office. However, they never lose sight of the fact that it is the tax money that is being spent and naturally resent the official in charge being given too much publicity for spending. The official who can keep his balance and walks the line between oblivion and adulation has gone a long way to being classed as a success.

The Division of Entomology of the Department of Conservation has many duties specified in our law. One of the principal of these duties is to attempt to eradicate or control any new insect pest or plant disease that may be found in our state. I believe that the most serious insect pest that has invaded our borders to date is the Japanese beetle. It is about this beetle that I shall tell of the progress so far, in our control program against it, and, why I believe we have met with such satisfactory results. Before taking up the record of this pest in Indiana, a short summary of its entry into the United States and its record of alarming increase and spread will explain why we believe that the money and effort spent on its control in Indiana has been justified. We firmly believe that these efforts should be continued as long as the cost of the work does not exceed 2 or 3 per cent of the losses caused by the insect in the states now heavily infested.

During the summer of 1916 two nursery inspectors of the New Jersey Department of Agriculture collected several beetles with which they were not familiar. These beetles were found in a nursery at Riverton, New Jersey, and were later identified by E. A. Schwartz, of the Bureau of Entomology at Washington, D. C., as a species common to Japan, named *Popillia japonica*. Although an intensive search was made in and around the nursery during the summer, only about a dozen beetles could be found that year. All the evidence now available leads to the belief that these beetles were brought in as grubs in shipments of either Azaleas or Japanese iris from Japan to the nursery in Riverton in 1912. If they came in on plants imported in 1912, they were either slow in becoming established, or the search for the beetles was not very intense, or, possibly, was made too late in the season. We must remember that comparatively nothing was known of the habits of this insect the year it was found.

An intensive survey of 1917 disclosed the fact that the beetles infested an area of 2.7 square miles in the vicinity of the nursery at Riverton. The surveys of 1918 showed that the beetles covered an area of 6.7 square miles, and in 1919 the area covered had increased to 48.3 square miles, and in the center of the area that year the beetles could be found

in abundance. In 1920 the infested area included 92 square miles and the beetles crossed the Delaware River and had infested 11 square miles in Pennsylvania. The year 1922 showed 773 square miles infested and in 1923 the area had increased to 2,442 square miles. This is a numerical history of the beetle's ravaging progress in the State of New Jersey and it told us in Indiana what we could expect from this pest when it came here. There was never any doubt but that our state would eventually have the Japanese beetle. I have given the record of the progress of this pest for seven years because we first found this insect in Indiana seven years ago. Later on I wish to compare our infestations with this early record in New Jersey and Pennsylvania.

It is true that all this infested area in New Jersey and Pennsylvania had been quarantined and inspectors were placed on all roads to examine all vehicles to see that beetles were not carried on produce or flowers leaving the area. Research work was started in an effort to find a control that would be practical. After 1923 the beetle infestation increased rapidly in numbers and in areas, and each year the major amount of work that was done for control on these outlying infestations was to include the area in the quarantine zone.

The State Entomologist's Office in Indiana never did believe that enough effort on control work had been made on the fringe of this expanding area of infestation in the eastern states. Our office thought then, and our efforts in Indiana have since proved, that if these outlying infestations had been cleaned as fast as they were found, it would not have been necessary to take many of the large areas into the quarantine zone which showed only a slight infestation. The quarantine lines should have been held closer to the heavier infestation; this would have greatly retarded the spread. However, the cost of a control program, such as the Japanese beetle project, is handled on a fifty-fifty basis between the states infested and the federal government. The states never had available money for such a control program and always had to wait until their legislature met and appropriated funds. This always proved too late to do effective work; the money should have been appropriated and made available *if* and *when* the insect was found in any section of any state.

Realizing that Indiana could not escape an invasion of this pest, in 1926 we asked for and the legislature granted to us, the right to use money from a special fund, if the presence of the Japanese beetle should be found in Indiana. So, six years previous to the appearance of the Japanese beetle in our State we were ready with plans and money to start our control program. This special fund was created for the control of the European corn borer. The legislature specified that the money could only be used for the eradication of the European corn borer and the Japanese beetle, if its presence should be discovered in the State. Later, the legislature included Dutch elm disease because this disease had been found in Marion County. That session of the legislature added a clause to our appropriation, stating that the funds allocated could now be used for the control or eradication of any new insect pest or plant disease which might appear in the state.

We fervently hope that an appropriation of this kind will be made each legislative year, and if the necessity for its use does not materialize, that the money will not be spent for any purpose other than that for which it was allocated.

I have given a brief history of the Japanese beetle in its early years and explained why and how we had funds to start work on the control of this pest when it was found in Indianapolis in 1934. Probably the first Japanese beetle was found in Indianapolis in 1933, but no one in the State Entomologist's Office saw it.

During the year of 1933 we had a telephone call from a woman in Indianapolis saying she had seen a girl who had found a Japanese beetle, and that she had asked the girl to take it to our office for positive identification. This woman said she had formerly lived in the east and had seen millions of these beetles. We had no way of locating the girl because the woman had not asked for her address. The girl failed to bring the beetle to the office, but we credited the woman's story sufficiently to ask the Bureau of Entomology at Washington, D. C., to send beetle traps into Indianapolis to determine if we had an infestation of this pest. The presence of the 800 traps which were placed in the city that year proved that we did.

The beetles were first discovered in Indianapolis in an area at 30th and Meridian streets and at Willard Park on East Washington street. Only 17 beetles were found in 1934, and because we had money available through appropriation, control work was started that fall. One thousand pounds of arsenate of lead was applied to each acre of ground within 300 feet of any trap in which a beetle was found. That season we had to treat 40 acres, using 40,000 pounds of arsenate of lead. Due to the finding of this infested area in Indianapolis, we thought it advisable to place traps in all the large cities of the state.

In 1935 traps were placed in Indianapolis, South Bend, Fort Wayne, Richmond, Jeffersonville, New Albany and Evansville. No beetles were trapped except in Indianapolis, where a new area near South and Delaware streets was found infested. In the area at 30th and Meridian streets, and this new area, a total of 59 beetles were found. The infested zone at South and Delaware streets has been harder to eradicate than the area at 30th and Meridian. We believe we are constantly receiving beetles in this place from produce cars which are unloaded at South and Delaware, so we are continuing the treatments each year in that district, if beetles are found beyond the limit of the area that has previously been treated. So far we have been able to hold the number of beetles in this area to a minimum.

In 1936 thirty beetles were found in Indianapolis in two areas; 5 beetles were found in Fort Wayne and 2 beetles in South Bend. In 1937 only 12 beetles were found in Indianapolis, 18 in Fort Wayne, 43 in Logansport, and one was found in Elkhart. In 1938 ten beetles were found in Indianapolis, 20 in Fort Wayne, 8 in South Bend, 9 in Logansport, 2 in Elkhart and one in East Chicago. In 1939, seventy-six beetles were found in Indianapolis, 109 in Fort Wayne, 98 in Logansport, 4 in Elkhart,

3 in Bluffton, 2 in Warsaw, 21 in Whiting, 1 in Muncie and 1 in Richmond. We found during that year that we did not have enough money available to purchase the 200,000 pounds of arsenate of lead necessary to treat the 200 acres which were infested in the state.

About 25 acres in Christian Park in Indianapolis needed the arsenate of lead treatment, so I went to the city council and asked them for $2,500 to purchase the material for the work in that vicinity. They kindly and understandingly granted this request. I shall always feel grateful for the unquestioning assistance the council gave me, for without this material help, our program for that year could not have been completed.

In 1940 we found 52 beetles in Fort Wayne, 12 in South Bend, 13 in Logansport, 76 in Elkhart, 7 in Richmond, 59 in Warsaw, 4 in Whiting, 2 in New Castle and 164 in Indianapolis.

The increase of numbers of Japanese beetles found in Indianapolis in 1940 is largely due to a new area found below South street between Illinois and West streets. Here we discovered an infested area that covered close to 20 acres. This location is a trucking center and it again proves that such places must be carefully checked every two or three years.

An area of twenty acres near Christian Park will have to be treated this year. We believe that the beetles found here came from a railroad yard south of the Park. This year we trapped them on the vacant ground between the railroad and the Park.

May I emphasize the fact that we believe we can cope with these infestations if we discover them in time. There is always the lurking fear that we may find an area in which the beetles have been established a number of years and that this problem may necessitate the expenditure of more money than we have available. We have tried to anticipate this emergency by covering the state thoroughly with the beetle traps.

With the finding of 389 beetles in Indiana this year we must treat 200 acres of ground with arsenate of lead. These figures do not indicate that we cannot eradicate an infestation wherever we find it. It can and is being done. However, the area of heavy infestation to the east of us is coming closer to Indiana and each year we are finding more new areas of infestation. Just how many years we can continue this control work will depend on whether the legislature will appropriate sufficient funds to take care of this ever increasing number of new infestations. They have, in the past given us what we asked for. We have been very careful to hold our expenditures to a minimum and believe we can prove the money has been wisely spent.

Indiana is not the only state which is making an effort to stop the spread of the Japanese beetle. Kentucky, Michigan, Illinois and Missouri are doing the same type of control work as Indiana and accomplishing equally as good results. However, they have not had as many points of infestation as we have. Ohio did not have funds allocated for this work and when the beetles were found in that state they had to delay the control work waiting for an appropriation. As a result, the eastern section of that state is now under federal quarantine. Ohio is making a concerted effort to hold this pest from the western part of their state

and we are hoping they can and will continue to keep the barrier to the east of Indiana.

May I point out that this area in the central states is the only area that has ever made a real effort to check this insect. It has been customary to fold hands and say, What can we do? then decide to do nothing. It is and has been the opinion of the regulatory officials of the central states that what has been done here could and should have been done in the eastern states long before we had to start on the control program in this area.

As I have previously stated, this state program of control and eradication is done on a cooperative basis with the state and federal government; each bearing 50 percent of the cost. However, this basis does not seem fair when the central states are actually putting into effect a barrier zone which holds the Japanese beetle infestation from the states west of the Mississippi river. I believe the federal government should assume a larger share of the expense. If they would be willing to do this, the Japanese beetle could probably be prevented from passing beyond this barrier zone for many years. If isolated infestations should appear west of the Mississippi river, they could be treated as we have demonstrated feasible, and those states could easily hold the beetles to a minimum for at least another ten years.

For seven years in Indiana we have been able to continue our control program against the Japanese beetle because we had the available money which was appropriated for this work and we were not forced to wait a year or two before starting the needed control. This money was available because our office did not make each insect outbreak in our state a major catastrophe and demand funds for control work which normally should be done by the individual. Likewise, we do not use special funds for any purpose other than that for which they are allocated. Regardless of what the emergency might be, we will not violate any agreement made with the legislature.

I should like to make a special point in reference to a state official receiving an excess amount of publicity when dispensing with public funds. The public usually has only the information given out by the official and many doubts may sometimes creep into the public mind as to the real need of the work if the official appears too prominently in the notices. It is true that publicity is necessary, but you will find that if your program is an honest and sincere one, you cannot keep it away from the public.

I hope I have succeeded in making it clear to you that our failure to carry through to success the program of the control and eradication of the European corn borer, was largely due, as I have previously stated, to the over-emphasized publicity given to it. The headlines of the European corn borer publicity each day grew more lurid and direful than the ones appearing the previous day. This continued until there was a growing conviction in the State Entomologist's Office that all this unwarranted publicity was tending only to cause doubts in the minds of the farmers and the public in general that the corn borer program was a sincere and necessary one. Then to convince the doubting public that this

over-emphasized program was progressing normally, new stories with bigger and more arresting headlines were thought to be necessary. These flagrant headlines eventually appeared, but finally proved the medium through which the corn borer control program was defeated.

When the Japanese beetle was found in Indiana, there was no special publicity agency in Washington, D. C., to disseminate the Japanese beetle news for this state. All the publicity for this program affecting Indiana came from the Office of the State Entomologist. We avoided over-emphasis on all outgoing publicity for this control program and gave out only the information as to the names of the various towns in which the beetle traps were to be placed. When the trapping season in the Japanese beetle control program was completed, we always released a short story as to how many towns and in what area of these towns the beetles were found.

In the eastern states the research officials were finding natural controls for the Japanese beetle. The most promising of these parasitic controls seem to be two diseases of the larvae. We have given these natural controls no publicity in Indiana, because wherever they are known, the general public feels that all other methods of control work should be abandoned. There must always be a heavy infestation to establish these diseases so we hope it may be many years before Indiana will be in a position to introduce these methods of control.

If through the use of moderation in publicity of the Japanese beetle control program, we can convince the people that the work is being efficiently done and that we are having as much or more success than was promised seven years ago, I believe we can be assured of their continued and unquestioning support.

As it is, the papers and the general public have accepted the quiet fact that we are launched upon a program that requires much time. They believe we are sincere in our knowledge that this control program is vitally necessary and that we are going to do this work as inexpensively and efficiently as is possible.

ANTHROPOLOGY

Chairman: PAUL WEER, Indiana Historical Society

Dr. Thomas B. Noble, Jr., was elected chairman of the section for 1941.

ABSTRACTS

Section on Anthropology. PAUL WEER, Indiana Historical Society.—"Anthropology: The Study of Man," by Amos W. Butler, (read by title), appeared in the 1894 Proceedings of the Indiana Academy of Science. Attaining full stature of Amos Butler's forty-six year old prophecy, the first program of the Academy's Section on Anthropology, under title as such, was held at the 1940 fall meeting. In the first published Proceedings of the Academy, was printed a paper by T. B. Redding, of Newcastle, on "The Pre-Historic Earthworks of Henry County, Indiana". In the same volume two papers, read by titles, "Recent Archaeological Discoveries in Southern Ohio", and "Methods observed in Archaeological Research", were entered by Warren King Moorehead, distinguished pioneer in American Archaeology.

Throughout the years contributions on archaeological subjects continued to appear in most volumes of the Proceedings. A movement to organize a separate section began to make its presence felt in the early 1920's when the Archaeological Survey Committee was organized. Butler, W. N. Logan, A. J. Bigney, C. A. Malott, E. Y. Guernsey, and others were active in the promotion of the committee's work. The first meeting of the Section on Archaeology was held in 1935 at Wabash College, under the chairmanship of Eli Lilly. At this meeting papers were read by Mr. Lilly, Glenn A. Black, Thomas B. Noble, Jr., and Paul Weer. The next year Mr. Black became chairman. Under his leadership the section grew and developed in the broadening activities of its members. It was also at his suggestion that the section has been expanded to a Section on Anthropology.

Preliminary notes on the Archaeology of the East White River region. E. Y. GUERNSEY, Indiana Historical Society.—Along East White River and its tributaries and also along Patoka River, there have been observed abundant evidences of aboriginal occupation representing at least four culture groups of major importance. In addition there is surface evidence of still other occupations. These major occupations appear to include a primary group of midden-dwelling people of non-agricultural character, who made no pottery, had no smoking complex, and who buried their dead without ceremony within the shell middens upon which they lived in dwellings of unidentified pattern. It seems that these people were more primitive than were the midden-dwellers of Indiana Knoll, Ohio Falls, and Northern Alabama. We also observe in this region another occupation by a group almost as primitive as the midden-dwellers. They buried their dead however with more care, within low mounds of earth or sand;

these topped with slabs of limestone or sandstone. There appears to be an almost complete absence of grave goods. Contiguous to each of the stone mounds so far observed in the area there are more or less extensive village sites. At some of these the artifacts are crude including potsherds of crude cord marked pattern. At others there is displayed a more advanced culture pattern, of obvious Middle Mississippi origin, in which the pottery is shell tempered, handled or lugged, and often decorated with underlip chevron designs. Typical, also, are stone discoidals of large size and exceptional finish, very large human and animal effigy pipes (one of which is almost identical with that figured in West's Figure 2, Plate 129, as from Door County, Wisconsin).

It is possible to locate from pioneer records of Lawrence County certain camp-sites of historic Indian identity. Copper axes of Hopewell type have been found about Springville, in northwest Lawrence County. These and other typical objects suggest a contact with the occupants of Black's Worthington site.

The complex of culture manifestations suggests the importance of the region as a possible key to the determination of cultural sequences, and in particular to the scope of influence of Middle Mississippi culture upon the region of the Ohio as a whole.

On the trail of the Archaeologist. THOMAS B. NOBLE, JR., Indianapolis.—This paper dealt with observations made on a recent trip through Arch Canyon in southeastern Utah. This region, about one hundred miles from Meas Verde, represents an edge of the old Basket Maker-Pueblo culture. There are numerous ruins of both early and late type dwellings, but none are as easily differentiated as similar type ruins farther south in Arizona. The trip was made for the purpose of recording photographically some points of difference that were noted, not only in the ruins of dwellings but also in the material seen in refuse heaps. Many slides were made of characteristic material of this sort. These were shown at the meeting of the Indiana Academy, along with scenic and color slides depicting the topography and beauty of the region. A trip of a week on horseback was described, including some non-scientific observations on the comforts and discomforts met with in this sort of travel.

Archaeology at the Angel Mounds Site*

GLENN A. BLACK, Indiana Historical Society

For the past eighteen months the Indiana Historial Society, with the cooperation of the Works Progress Administration, has been exploring a large prehistoric Indian village and mound group known as the Angel Site, in Vanderburgh-Warrick Counties, Indiana. The site is, by far, the most interesting and spectacular aboriginal remnant in the state and occupies an important position in the archaeology of the Mississippi and Ohio Valleys.

Physically, the site is dominated by a large bi-level, truncate mound in the approximate center of the village, upon which stood the residence and council house of those who ruled the village. To the west stands a truncate mound, only slightly less imposing than the larger one, upon which a lesser chief made his residence. To the east and west, north and south, the fields contain ample evidence of the habitation of the people composing this prehistoric community. Surrounding the village upon all sides except the river side, is an earthen embankment upon which stood the log palisade, so necessary for the defense of the inhabitants. Smaller mounds cover the field in abundance, some of which may be of a domiciliary nature while others may contain burials of important personages.

Explorations to date have been carried on in the village, the palisade embankment and upon the second largest mound of the group. The village has been extremely productive of materials, representing the material attainments of the inhabitants and other culture traits such as domestic house types, fireplace types and method of burial disposal.

The protective embankment has produced evidence indicating the method used in the construction of the palisade, the main feature of which was projecting bastions at intervals of approximately one hundred and twenty feet, which permitted enfilading fire by those defending the village.

As in all mounds of the truncate pyramidal type, all evidence of the structures standing upon the top of the mound at the time the village was deserted, has been destroyed by cultivation, erosion and soil leaching. However, due to the custom of increasing the size of this type of mound at regular intervals, a floor previously used has been found seven feet below the top surface. Although at this writing the floor has not been completely explored, enough has been seen to indicate beyond question that the details of the structure formerly standing upon it will be clarified with complete exploration.

Archaeology during the past fifty years has passed through an interesting cycle. At the beginning of the period of intensive exploration the principal purpose of an expedition was to obtain specimens to be used largely for display purposes. Through progressive stages this function

*Presented before the general meeting.

was superceded by the desire on the part of research workers to determine the story that such specimens might tell, with a consequent transposition of emphasis upon the significance of specimens rather than the objects themselves. Today it is becoming more apparent that the archaeologist, with a conscientious desire to exhaust completely the possibilities of the site being studied, must again become a procurer of specimens. This time, however, the specimens are not necessarily procured for display purposes but primarily for the purpose of placing them at the disposal of workers in unrelated but cooperative fields of research. Every archaeological site produces material of interest to every science and, in turn, every science can contribute to the knowledge and understanding of the archaeological field worker. The botanist, the chemist, the zoologist, geologist, metallurgist, and physicist by exhausting the specialized studies of the various elements from a site, can augment tremendously the story of man's past accomplishments and experiences. Mathematical equations applied to statistical tables of culture trait occurrences remove the human element entirely from conclusions that are the necessary result of every exploration. Every person attending a scientific gathering such as the one for which this paper is prepared can find, for the looking, something of interest in archaeology.

Indians of Indiana

ERMINIE W. VOEGELIN, Greencastle

Indiana, like Ohio and Kentucky, is rich in archaeological remains which indicate that in prehistoric times the Ohio Valley region supported a large native population. What then happened to virtually clear the Ohio Valley drainage of this population prior to the advent of the whites? Attempts to explain this usually suffer for lack of a chronological roster of all tribes directly or indirectly known to have occupied the area in question. The aim of the present paper is to supply such a chronological roster for the state of Indiana.

(1). **Siouan groups.** Indirect evidence indicates that certain Siouan groups formed part of the population of the Ohio region, and more particularly of Indiana, during late prehistoric and protohistoric times.

One of these Siouan groups was the Quapaw. In Father Gravier's account of his trip down the Mississippi in 1700 it is stated that the Illinois and Miami called the Wabash and lower Ohio the river of the Akansea (Quapaw), because the Akansea formerly dwelt on it. The Quapaw occupancy of Indiana terminated prior to 1540, however, since at that date De Soto found this tribe situated on the west bank of the Mississippi, north of the mouth of the Arkansas river.

Toward the end of the seventeenth century a tribe (recently identified by John R. Swanton as the Ofo or Ofogoula) was reported as having formerly lived along the Ohio in what was later southern Indiana or southern Ohio. This group is referred to in early French sources as the Monsoupelea (Mosopelea, Mansopelea, etc.), which was probably the Shawnee designation for the Ofc, since the Shawnee name for the Ohio river is Msipelewa or Big Turkey river, and streams were often referred to by the name of the people living on them. Linguistic research has recently shown that the speech of the Biloxi, a tribe in Mississippi, the Ofo, and the Tutelo, a Virginia group, constitutes a subdivision of the Siouan stock; it seems probable that the point of dispersal for these three tribes was the Ohio valley region, and that at least one of them, the Mosopelea or Ofo, continued to occupy the region almost until historic times. But like the Quapaw, the Mosopelea removed from the Ohio southward down the Mississippi before the Ohio region was actually explored by the whites. During the last quarter of the seventeenth century the Mosopelea are referred to as living at various locations on the Mississippi, south of the Ohio; in the early eighteenth century, under the name Ofogoula, they were situated on the Yazoo river in Mississippi.

(2). **Earliest Shawnee.** Two other tribes, the Algonquian-speaking Shawnee and Miami, have often been mentioned as early inhabitants of Indiana. The most explicit reference to the Shawnee on the Ohio river in the seventeenth century is to be found in the *Relation* by Abbe Gallinée. Gallinée states that, in 1668, some Seneca told La Salle that the Ohio

river "had its source at three days' journey from Sonnontouan [near Naples, Ontario county, western New York] and that after a month's travel he would reach the Honniasontkeronons [Andaste?] and the Chiouanons [Shawnee], and that after having passed these and a great waterfall which there was in the river [the rapids or Falls of the Ohio?] he would find the Outagame [Fox?] and the country of the Iskousogos." Marquette also refers to the "Chaouanons" or Shawnee in the account of his trip down the Mississippi with Joliet in 1673. He remarks that the Waboukigou, which was a name often given to the Ohio below its confluence with the Wabash, "flows from the lands of the East, where dwell the people called Chaouanons in so great numbers that in one district there are as many as twenty-three villages, and fifteen in another, quite near one another." On Joliet's sketch maps the Shawnee appear close to the eastern bank of the Mississippi and also south of the Wabash-Ohio.

However, neither La Salle nor Marquette nor Joliet nor Tonti nor Gravier, to mention only a few of the early French explorers, penetrated inland far enough east of the Mississippi to encounter the Shawnee *in situ*, and all statements made by these authorities are based on hearsay evidence. On the other hand, traders and settlers made definite contacts with various Shawnee groups east of the Allegheny region prior to the close of the seventeenth century and in the early eighteenth century, which would seem to indicate that the Shawnee were probably situated farther east and south than Gallinée and Marquette put them. The evidence for the Shawnee as one of the early historic groups of southern Indiana is therefore questionable.

(3). **Earliest Miami.** The claims of the Miami to aboriginal occupancy of Indiana are most clearly set forth in a statement made by Little Turtle, a Miami leader, in 1795. Little Turtle said:—"My fathers kindled the first fire at Detroit; thence they extended their lines to the headwaters of the Scioto; thence to its mouth; thence down the Ohio to the mouth of the Wabash, and thence to Chicago over Lake Michigan." However, despite this positive claim, the title of the Miami to Indiana and western Ohio is by no means clear, for two reasons. Little Turtle was not by blood a Miami, although he was raised among this tribe and served as a war leader. In an account of the Miami compiled and written at Fort Wayne thirteen years after Little Turtle's death, C. C. Trowbridge states on the authority of Miami informants that "The Little Turtle is not considered a Miami;" he was, it seems, the offspring of a Mahican man and an Ioway girl who "settled among the Miamies & had a great many children, of whom the eldest was Little Turtle." A second and more serious reason for not accepting the Miami as the aboriginal proprietors of Indiana lies in the fact that in 1658 some of the Miami, at least, were reported by Gabriel Druillettes as living at the mouth of Green Bay, Wisconsin. In 1670 Nicholas Perrot actually visited a Miami village at the headwaters of the Fox river, in Wisconsin. Within a decade these Miami had moved south from Fox river and had formed settlements at Chicago and on the St. Joseph river of Lake Michigan. It is here, in 1680, that their history as Indiana Indians would appear to begin.

(4). **Historic tribes.** Despite the fact that Indiana presents difficult problems in the identification of its early occupants, this region was by no means devoid of an Indian population immediately preceding and during the early period of white penetration. In the eighteenth and early nineteenth centuries both Indiana and Ohio became refuge areas for a large number of Indian tribes or segments of tribal groups. In Indiana alone a dozen historically intrusive groups lived within the borders of the state during the last two centuries. Some of these, such as the Mahican, Nañticoke, Mohegan, Delaware, Munsee, and Shawnee, were originally from the eastern seaboard region and had been pushed westward by the press of white settlement. Others, such as the Kickapoo, Potawatomi, Miami, Piankeshaw, Wea, and Huron, were from the Great Lakes area. With one exception all groups who migrated to Indiana spoke Algonquian languages; the exception was the Huron, whose speech belongs to the Iroquois family.

(5). **Miami.** Of the historic tribes which moved into Indiana, the Miami and two closely related groups, the Wea and the Piankeshaw, occupy a foremost place. The early locations and movements of this unit will therefore be given first consideration.

As has been noted, in 1680 the Miami were located on the St. Joseph river of Lake Michigan, in the extreme northwestern part of Indiana, and also in the vicinity of Chicago. During the early decades of the eighteenth century the Miami proper occupied the country north and northwest of the upper Wabash. The Wea and Piankeshaw were located farther down on the same river, around Ouiatenon and at the mouth of the Vermillion river near Vincennes, respectively.

From their location northwest of the Wabash the Miami gradually moved east in Indiana. Kekionga (now Fort Wayne), at the junction of the Maumee and St. Joseph rivers, became their principal town. During the middle part of the eighteenth century the Miami removed even farther eastward and established towns in northwestern Ohio, but after 1763 they abandoned these Ohio settlements and moved back into northeastern Indiana, where they remained until many of them sold their lands and removed west of the Mississippi, around 1827. One band occupied a reservation in Wabash county, Indiana, until 1872, when the land was divided among the 300 members. The Wea and Piankeshaw removed to the west from their villages near the Wabash at intervals between 1800 and 1832; in 1820 the Wea sold their last lands in Indiana, at the mouth of Raccoon creek, in Park county.

The Miami, Wea, and Piankeshaw were tribal and dialect units: all three spoke one mutually intelligible language. In 1825 C. C. Trowbridge was told by a Miami informant that the Miami could understand perfectly the speech of the Wea and Piankeshaw, as well as that of two neighboring Illinois groups, the Kaskaskia and Peoria.

(6). **Mahican.** In 1721 a band of Mahican, originally from the upper Hudson river valley of New York, established a village on the banks of the Kankakee river in Indiana. Other members of this tribe also lived in Indiana, on the banks of the White river, around the close of the

eighteenth century. One mixed Mahican group known as the Stockbridges removed from New York to Indiana under their chief, Austin E. Quinney, in the early nineteenth century, but in 1822 this group bought land near Green Bay, Wisconsin and moved north.

(7). **Huron.** The band of 119 Huron warriors and their families who lived in Indiana for a few months in 1748 was under the leadership of Orontony, or Nicholas, a Huron chief who had proposed that the Ohio Valley-Great Lakes tribes league together to destroy the French posts, but whose plan became known to the French and failed of execution. In April, 1748, Orontony destroyed his village on Sandusky Bay and removed with his people to the White river. During the summer or fall of the same year he and his group left Indiana for the Illinois country, where Orontony died that same fall.

(8). **Delaware.** Around 1770 the Delaware and the closely related Munsee received permission from the Miami and Piankeshaw to occupy the country between the Ohio and White rivers. There were a few Delaware towns in southern Indiana after 1770 also, but the main settlements of the Delaware and Munsee were on the upper course of the west fork of the White river in Hamilton, Madison and Delaware counties. A "Delaware Town" is also mapped four miles from Fort Wayne by Thomas Ridout (1788) and is mentioned by Henry Hay (1789); the latter states that this was the winter camp of George Girty, a Pennsylvanian who spent his life among the Delaware and Shawnee Indians.

The majority of the Delaware in Indiana left the state in 1818, after releasing their lands on White river. At the time of their removal the White River Delaware numbered about 800 persons.

(9). **Kickapoo.** Almost coincidental with the entry of the Delaware and Munsee into Indiana from the east was the Kickapoo entry from the west. After the destruction of the Illinois confederacy in 1765 the Kickapoo moved south from Wisconsin to Illinois. There the tribe split, one part gradually moving westward while the other part moved eastward into Indiana. Despite Miami and Piankeshaw opposition the new entrants settled on the Vermillion and Wabash rivers and became known as the Vermillion band of Kickapoo. Trowbridge comments upon the fact that these Indiana Kickapoo had intermarried with the Miami and had greatly assimilated to the latter in language and culture. The Kickapoo were also strongly influenced by the Shawnee Prophet when he lived in Indiana during the first part of the nineteenth century. In 1809 the Kickapoo ceded their lands on the Wabash and Vermillion rivers and moved west of the Mississippi.

(10). **Nanticoke and Mohegan.** Originally from Maryland, the Nanticoke entered Indiana about 1784 (presumably with some Connecticut Mohegan), and lived on the White river a short distance west of the Delaware. After 1818 the Nanticoke removed west of the Mississippi with the White River Delaware group and the Mohegan who had come west with them. The combined number of Nanticoke and Mohegan who left Indiana in 1818 is estimated at 200.

(11). **Shawnee.** By 1788 some Shawnee were living in northeastern Indiana, while others were beginning to roam through southern Indiana. Kakinathucca's band, probably belonging to the Pekowi division of the Shawnee tribe, was in April, 1788 hunting and making sugar at a winter camp in the extreme southeastern part of the state. Thomas Ridout, an English captive with this band, states that southeastern Indiana was a hunting place for this group of "Shawanese Indians" who, up to 1787 had been living on the Scioto river. After they had finished their sugar-making in the spring of 1788 members of the band removed westward across the southern part of the state to a location below Vincennes, near the junction of the Wabash and White rivers, where the women planted their crops. From that spot Kakinathucca and his people continued their trek north along the Wabash to Fort Miami (Fort Wayne). Ridout mentions two Shawnee chiefs, Blue Jacket, a white captive who spent his life with the Shawnee, and the Great Snake, as living a mile or two distant from Fort Miami. Henry Hay, who was at Miamitown (Fort Wayne) a year later, also refers to Blue Jacket, the Great Snake, and a "Chilicothe Village" of Shawnee, of which "Black Bairde" was chief. In the closing decade of the eighteenth century then, part of the Shawnee had removed from northeastern Ohio to villages in the vicinity of Fort Wayne, while other Shawnee were in southern Indiana, and still others in east-central Indiana. Of these latter we know that there were some on the White river, where they had moved from Ohio in 1798 by invitation of the Delaware, and another group, totalling 500 persons, which in 1816 was living 40 miles north of the White river, in a town on the Mississinewa, a branch of the Wabash.

It was in a White river settlement that the Shawnee Prophet had the vision which caused him to begin preaching among the central woodland tribes for a return to their native mode of life and the espousal of his brother's, Tecumseh's, cause. The Prophet gained many followers, but few of the Shawnee were won over to his cause. In 1808 he moved to the Wabash after a brief stay in Greenville, Ohio, and established a town near the mouth of Tippecanoe creek. The Kickapoo and Potawatomi were then in western Indiana, and many of them became converts to the Prophet's cause. After the battle of Tippecanoe in 1811 the Prophet and his band left Indiana and lived for several years at Fort Malden, at the mouth of Detroit river on the Ontario side.

The Shawnee at Fort Wayne and those on the White and Mississinewa rivers moved from Indiana, westward across the Mississippi, during the first quarter of the nineteenth century. In 1832-33 Shawnee from Wapakoneta and Lewistown, Ohio, journeyed across Indiana on their way west to join their fellow tribesmen in Kansas.

(12). **Potawatomi.** After 1765 the Potawatomi gradually spread south into southern Michigan and in 1795 they notified the Miami that they intended to move farther south into Indiana. This they did in spite of Miami protests. Around the close of the century numerous bands of Potawatomi had established villages in the northern part of the state, from the Kankakee river region eastward. Other groups of Potawatomi settled in Illinois. The bands in Indiana around the headwaters of

Tippecanoe river were known as the "Potawatomi of the Wabash." These bands sold their reserves in Indiana in 1836 and agreed to remove west across the Mississippi within two years. Many of the Potawatomi in Indiana refused, however, to leave their homes until they were driven out by military force in 1838.

With the Potawatomi ended the migration of Indian groups to Indiana, for at the same time the Potawatomi were moving into the state white settlers were beginning to cut down the forests and establish homes in the region. Within two decades after the entrance of the Potawatomi the issue as to which group, Indian or white, would possess the state had been settled. By 1838, the year the last Potawatomi group was forcibly removed, Indiana was virtually cleared of its Indian population save for a few Miami, the most persistent of the Indiana tribes.

Cultural Complexities of Southwestern Indiana

GLENN A. BLACK, Indiana Historical Society

The area included within the scope of this brief paper consists of eight counties in southwestern Indiana. On the south, north of the Ohio River, are the counties of Posey, Vanderburgh, Warrick, Spencer and Perry. Contiguous to this southern tier, Dubois, Pike and Gibson counties are south of White River, while the Wabash bounds the region on the west. Extending from the low flood plains of the Wabash and Ohio rivers, north and east, to the rolling uplands of Spencer and Perry counties, a considerable variety of flora and geographical features were available for habitation by people, whose selection of spots to live upon, at times, seem somewhat choosy.

Due to its geographical position the area in question undoubtedly was of strategic importance in times past. The proximity of major water routes such as the Wabash, Tennessee, Cumberland and Green rivers converging as they do upon a major barrier such as the Ohio River in a country abundantly supplied with every requisite for primitive life, it should be surprising indeed if a complexity and abundance of material remnants of vast numbers of aborigines were not found.

During the course of the exploration of the Angel site in Vanderburgh County very little time has been available for reconnaissance of the surrounding area. It is of utmost importance, in connection with the exploration in question, to be familiar with the cultural complexes of the environment and with this in mind, surface survey work has been carried on as time would permit.

By no means all of the material forming the basis of this paper has been obtained personally. The willing assistance of local collectors and students, both past and present, have contributed much, if not most, of the information involved.

Within this area evidence exists of a prolonged habitation by unrelated ethnic and culture groups. Eliminating entirely the questionable significance of Folsom points, found occasionally over the area, we should inaugurate our discussion with the material found locally, indicating a relationship with the pre-pottery shell mound peoples to the south. Two sites in the area have such a relationship. One, located in Dubois County, near the town of Portersville, will be the subject of a forthcoming report by the Indiana Historical Society; the other is located in Pike County, northwest of the town of Coe, on a small tributary of the Patoka River. The site in question was excavated during the winter of 1939-40 by a group of local enthusiasts and little data, not of a material nature, is available. The material recovered is in the hands of Mr. Reavis Campbell, of Boonville, to whom I am indebted for many courtesies. The material from the two sites is such as to imply a marked affinity with the peoples responsible for the shell mounds of Green River in Kentucky and Tennessee River in Tennessee and Alabama. In some respects the two

sites are at variance. The Dubois County site produced no pottery whatever while the site near Coe was ceramic bearing. The methods employed in the exploration of the latter site, however leave much to be desired and it is possible that the limited amount of pottery discovered was not a true part of the shell mound complex. The Coe site is at variance with the Dubois County site in another respect, in that it produced some material indicative of an entirely different culture and which will be mentioned again hereafter. It seems inevitable that the shell mound peoples should be considered as the earliest group inhabiting the area.

At several places along the Ohio River in Spencer, Vanderburgh and Posey counties sites are found which produce distinctive sherds of clay and lithic-tempered wares. This type of material has rather a wide distribution but locally, at least, is limited almost exclusively to deeply buried sites on the banks of the Ohio River. In association with this type of pottery large stemmed points are found and in at least one instance a bell pestle was found on a site producing this type of ware. The affinity of this material is with the Baumer component at the Kincaid site near Metropolis, Illinois, where it underlies the Middle Mississippi manifestation of the people responsible for the large mounds found at Kincaid. The Baumer is an early Woodland manifestation always underlying Mississippi where the two are found in association. The possibility of stratification is present in at least one Vanderburgh County site, which, if the destructive agencies of levee construction have not been too complete, should be explored with profit.

The Hopewellian complex is represented in the area at several points but little is known regarding it, to date. Hopewellian material has been found in Posey County and in Warrick County. Some of the material traits produced from a shell mound near Coe have a marked Hopewellian affinity. It would seem, on the basis of data available elsewhere, that Hopewellian should be post-Baumer.

A site in Warrick County, south of Yankeetown, produces a type of pottery exotic for Indiana. The site in question is on the caving banks of the Ohio River and, if the destructive forces now active continue, it will not be long before the entire site is destroyed. Surface collections have produced a type of extremely well made, thin, clay-tempered ware having clay as the aplastic and bearing upon the surfaces incised conventionalized designs. As an adjunct to the incised technique certain sherds have notched fillets upon the rim. Inside notching of the lip is a characteristic and notches were also found on the rim below a plain rim band. In association with these sherds, upon the surface of the site, are sherds of Middle Mississippi ware. This coincidence of material suggests either cultural stratification, so thinly separated that cultivation has mixed the two, or contemporaneity of the two complexes.

A site near Mt. Vernon was brought to my attention by a local collector, J. J. Geringer, of Evansville. The site in question is of large proportions and should, perhaps, be considered as a series of sites rather than as one site. Surface collections exhibit a ceramic range startling to behold, including plain ware having a micaceous sand content, a simple stamped ware also having a high micaceous sand content, clay-tempered

sherds bearing surface treatments of Hopewellian and Marksville type, gray sandy ware bearing complicated paddle stamped decorations of the Swift Creek form, red-filmed ware, Middle Mississippi sherds and cord-marked sherds which may be Mississippi—either Upper or Middle—or Woodland. It goes without saying that nothing of a definite nature can be said of such an important site when any statement must necessarily be based upon superficial observations. The site in question must be explored, in part at least, for the implications carried by the ceramic complex are tremendous and of far reaching importance.

The Mississippi manifestations in the area are many and considerably varied. The Angel site, in Vanderburgh County, dominates the scene by reason of its spectacular physical features. Explorations now under way suggest that the habitation was rather early for Middle Mississippi and that the regional affinity for the site will be to the southeast, in Georgia and Alabama.

Another Middle Mississippi site, near the mouth of the Wabash River, was explored many years ago by Clifford Anderson for Warren K. Moorehead. Although this site was definitely Middle Mississippi, certain elements within it suggest an Upper Mississippi lateness to the habitation and, in this respect, varies from the Angel site.

In summation we have seen that the time span for the area is a long one. That there are integrations, culturally, from one site and from one period to the other, is suggested by the material at hand. It is to be hoped that certain of these sites may be tested before explorations in the area are completed. The implications cast by the presence in a limited region by abundant materials of unrelated types are too important to overlook. Stratigraphic tests within this area may go far towards the solutions of chronology and sequence of habitation for many of the culture groups inhabiting the Ohio and Mississippi valleys.

Surface Pottery from Marion County Indiana

J. C. HOUSEHOLDER, Indiana Historical Society

On the famous Strawtown site on White River in Hamilton County a most unusual combination of pottery sherds was found some years ago. This was first discovered by finding a very large rim sherd, with attached handle, carrying the type of decoration known as "Fort Ancient." Before that discovery the sherds found at Strawtown were of the design known as Woodland; the type believed to be predominate on the majority of Indian village sites in this section of Indiana. With the discovery of this large sherd the Strawtown earthworks, refuse pits, and villages were searched over many times for artifacts, pottery, and archaeological material pertaining to the peoples who lived here.

Continued investigation at Strawtown and subsequent work by the writer in Marion County has revealed the fact that the mingling of Fort Ancient and Woodland sherds on the surface on many sites in this area is a predominate characteristic of these sites. The two types just mentioned are typical of many village sites in Marion County. At the present time there are 35 villages, 12 or more camp sites, and 2 burial places which exhibit this combination. At least 25 of these villages are located on White River, which runs through the central part of the county. Also a number have been found on Fall Creek which enters Marion County at its northeast corner and runs in a southwesterly direction until it flows into White River near West Tenth street and White River boulevard about one-half mile west of the Indianapolis Hospital center.

One-half mile north and west of this point on the east side of the river between the Indianapolis Baseball Park and the Emricksville bridge on the north side of state road 34 three villages were found: two on the first terrace, and one on the second terrace. Here we find both Woodland and Fort Ancient pottery sherds. I would mention the fact that at the site on the second terrace many triangular points, to the probable exclusion of other forms, was the feature of the stone artifact finds; while the two sites on the first terrace produced not only triangular but also stemmed and notched points. This is one of the interesting problems—the discovery of triangular points to the exclusion of other forms on one village site, and then the combination of triangular and stemmed or notched points on an adjacent site which from all other appearances is identical to its neighbor.

It is well to emphasize here that on these Marion County village sites I have found on the surface Fort Ancient sherds classified as belonging to the Upper Mississippi phase of the Mississippi pattern with sherds considered diagnostic of the Woodland pattern; and also in physical proximity on many sites triangular points which may be diagnostic of the Mississippi pattern and types of stemmed and notched points generally considered diagnostic of the Woodland pattern.

Moreover a strange circumstance presents itself in the probability that this mingling on the surface of so-called Mississippi and Woodland artifacts is restricted to Marion County and a portion of Hamilton County to the north. As I have mentioned above the majority, probably all, of the villages lie on White River or its tributaries, in an area extending from central Hamilton County to the southern boundary of Marion County. A persistent effort to trace this pottery manifestation on down White River as it flows south into and through Morgan County has failed to find such a combination.

I have tramped the shores of White River for its entire journey through Morgan County and in the places where villages should have been found on the basis of discoveries in Marion County no sites were to be found, except one village two or two and a half miles south of the Marion County line. This site was on a knoll about one-fourth mile back from the river. Here I found very few pieces of pottery, and one of them, a very small sherd fragment with a Fort Ancient trailed design; the majority of sherds were Woodland. This is not a final analysis, however, because I am inclined to feel that there may be villages under the heavily silted first terrace. This, of course, is conjecture and the fact remains that on the first terrace and at various places on the second terrace where I looked for villages none were to be found. Contrast this with the heavily covered villages in Marion County, and on up into Hamilton County as far as the Strawtown site. Above Strawtown and on into Madison County I found an absence of village sites bearing this combination of pottery.

Therefore, as far as careful search will permit me to state the case, it appears that the combination of pottery types and projectle points apparently is localized in Marion County and a portion of its neighbor to the north, Hamilton County.

There is a village north of Thirty-eighth street on the east side of the river. The property belongs to the Indianapolis Water Company, and covers 113.50 acres. This strip of land is in a very large turn in the river, and there are at least five different places where pot-sherds may be found, due to the high water in the spring cutting a very large wash from the north side of the field to the extreme south edge. This wash cut the village site to some extent. Both Woodland and Fort Ancient sherds are found. Projectile points of stemmed and notched forms are most prominent on this site. To the west approximately 500 feet, the river, during the high water, has silted this village. There are sherds for at least 200 feet east and west and the same distance north and south—both Woodland and Fort Ancient. Also were found triangular points, and a few stemmed projectle points, hammer stones, anvils, burnt rock, and animal bones. Going to the west edge of the field there we find another site. There have been hundreds of sherds found here of both Woodland and Fort Ancient. Triangular points are the most outstanding; there are very few of the other types along with the sherds. Also there are two rather crude celts of gray slate, three granite celts (all broken), two broken slate gorgets, animal bones, shell, and burnt rocks. There are a few places in this field where the sherds are very

small. Some of the sites are so close together that possibly a combination of 3, 4, or even 5 may represent pottery manifestation embracing one big village. This is noticeable at several of the sites, and reminds us of the large Fort Ancient sites in southern Indiana. This condition is met on the site east of Michigan road and on the north side of the river. Here we find the discoloration in the top soil with pottery, burnt rock, and animal bones. The ground rises after leaving the bank of the river and continues to rise to the east where it joins the first terrace. This is filled to some extent with a silt on the lower bank or first terrace at the east end of the field. At this point the high water has cut through a village, which is 4 or 5 feet below the present level of the first terrace. The fire pits and burnt rock were visible approximately 2 feet above the bottom of the wash on the north side of the first terrace in the spring of 1940. A broken stone axe, projectle points, both types of pottery, and a very large animal bone (unknown) were found on the surface.

The surveyor is under the impression the village is located between the wash and the river bank to the west and south. In other words it appears that high waters have washed out the center of the village and left evidence of its remains on each side of the wash.

Dr. J. H. Oliver's farm is located on White River in Sec. 17, 133 acres, and Sec. 20, 27 acres. The two sections join on the north and south. In April, 1939, this village site was surveyed by Mr. Eli Lilly, Mr. Glenn Black, Mr. Paul Weer and the writer. The party gathered several hundred sherds, both Woodland and Fort Ancient, triangular points, projectle points, celts, two broken beamers, one bone awl, animal bones, elk teeth, and the antler of an elk. There were two pits very outstanding. Number one in the east portion of the wash measured 4′ 10″ N and S, 4′ 5″ E and W. Number two, 3′ 9″ N and S and 4′ E and W. This measurement was made from the red circle of burnt earth. The surface of these circles contained small particles of animal bone, burnt rock, and very few sherds. Twenty-five feet to the west of the top edge of the wash a cache of shell, animal bone, and a few sherds were found. Going to the south central part of the field the river has cut a village site to some great extent. Here we found ten charcoal circles from nine to fourteen inches across surface. These places may have been posts for a house. Shortly after this survey the ground was prepared for a stand of clover and the surface evidence was destroyed.

In conclusion, there is a great deal more to be done in Marion County and the adjoining counties to the north and south. This report will be continued.

Historical Results of Crow-Hidatsa Comparisons, According to Three Methods

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Proto-Siouan had already divided into four languages or groups in proto-historic times. We name these proto-historic languages or groups according to the presumable point of dispersal of the daughter languages of each. These last are the modern Siouan languages and our only source of data. In the following, parentheses give important dialects while brackets give recent locations of modern languages.

Proto-Historic Languages:	Modern Lauguages:
Eastern Siouan	Catawaba [South Carolina].
Ohio Valley Siouan	Ofo [Louisiana, Mississippi].
	Biloxi [Louisiana, Mississippi].
	Tutelo [Virginia].
Missouri River Siouan	Hidatsa [North Dakota].
	Crow [Montana, Wyoming].
Mississippi Valley Siouan	(a) Winnebago [Wisconsin].
	Mandan [North Dakota].
	(b) Chiwere (Iowa-Oto-Missouri) [Nebraska, Missouri, Iowa].
	Dhegiha (Ponka-Omaha-Kansa-Osage-Quapaw) [Arkansas, Missouri, Kansas, Nebraska].
	Dakota (Santee-Yankton-Teton-Assiniboin) [Wisconsin, Minnesota, the Dakotas, and somewhat west and north].

The Eastern Siouan group, now represented by Catawaba alone, is a result of the inspectional approach in the sense that Kroeber recently distinguished between this method, favored by anthropologists, and the comparative method or reconstructive approach, favored by linguists (4 p. 464).

The comparative method shows that a proto-Siouan sequence of sibilant-vowel-stop, as well as the affricate *-ch-*, is preserved only in Biloxi, Ofo, and Tutelo (the vowel is lost in the sequence and the affricate appears as a sibilant in other Siouan languages); and conversely that all three Ohio Valley languages changed from proto-Siouan in having a single consonant, *-n-*, where the other languages retain some form of the old cluster, *-m-* followed by *-n-*; that where all the languages changed from proto-Siouan, as in the case of the old sound *-q-*, the Ohio Valley languages all changed to one kind of sound not appearing in other Siouan cognates: a half dozen features of this kind establish Ofo, Biloxi, and Tutelo as a distinct Siouan group (5 and 6).

The inspectional approach failed to associate Biloxi, Ofo, and Tutelo in the Ohio Valley group, which required the comparative method not for corroboration but for discovery in the first instance. In contrast, casual inspection was overly generous in associating Hidatsa and Crow.

The unique error in Dorsey's famous paper of 1883 is his decision that Crow and Hidatsa are but dialects of one present day language (1 p. 920).

Such alleged intimacy, and more recent emphasis on very close affinity between the two languages, does not explain the striking differences which the following examples show (with orthography using doubled vowels for length, stop plus *-h-* for the aspirated fortis series, but *-sh-* as in English 'ship'; only one of many possible examples is cited for each general statement) (2 and 3).

(1). Hid. *t* (and *ht*), Crow *s*. Hid. *atáarits*, Crow *asáariky* 'he went out'; Hid. *ihtía*, Crow *isáa* 'big'.

(2). Hid. *t* (and *ht* and *th*), Crow *sh*. Lowie points out that in Crow phonology *sh* is replaced by *s* before *a* and *-u*. Some (but not all) instances of this correspondence can be shown to involve the alternating *sh*. Hid. *ruutíts*, Crow *rushí* 'he eats' beside Crow *rusúu* 'they eat'; Hid. *ipítiru* 'behind him', Crow *piishe* 'behind'; Hid. *tsáhti-*, Crow *táshi-* 'to be greasy'; Hid. *pathíts*, Crow *pashíky* 'he falls'.

(3). Hid *ts* (and *hts*), Crow *t* (which is replaced in Crow by *ts* before *i*). Hid. *úuwatsa* 'iron' and 'money', Crow *úuwate* 'iron'; Hid. *rúhtsits*, Crow *rútsiky* 'he takes' beside a Crow form cited by Lowie as *ruth* 'to seize' (not an affricate because a following *-i* is lacking; perhaps aspirated because *-th* is in word-final).

(4). Hid. *k* (and *kh*), Crow *ky* (which may be a positional variant of the velar stop: in most examples *ky* follows a front vowel or is the second member of a cluster, but in one example *ky* is initial, a position also possible for *k* in Crow). Hid. *háshkits* 'it is long', Crow *hashkye* 'long', but Hid. *kua*, Crow *kyo* 'that' (a demonstrative); Hid. *wikhá*, Crow *wikya* 'grass'.

(5). Hid. *k*, Crow *ts* (perhaps a frontal development of *k*, a possibility recognized by Lowie; but the following high, front vowel must have been present when Missouri River Siouan was one language). Hid. *awawáakits*, Crow *áwwatsiky* 'I sit' (Crow *-ww-* is actualized as *-m m-*, but in both languages *m* is merely a positional variant of *w*); Hid. *kíats* 'he fears it', Crow *tsiri* 'he fears'. The apparent converse (Hid. *-ts*, Crow *-ky* at the end of verbs) is not a sound correspondence but a use of two different verb-finals: besides *-ts* which is used in Hidatsa when the verb stands at the end of a sentence, there is also a verb-final, *-ak*, used for verbs in relative clauses. Crow seems to have lost the *-ts* form and the Crow verb-final *-ky* is used more widely than the corresponding *-ak* in Hidatsa (see 4, above).

(6). Hid. *-i* (and *-a*, and *-u*), Crow *-e* (but alternating with medial *-a-* and with final *-a*, under certain morphological conditions). Hid. *tsíiri*, Crow *shiire* 'yellow'; Hid. *tsuwáta*, Crow *tsiwúse* 'brains'; Hid. *ihpú*, Crow *uhpé* 'end, tip'.

(7). Certain sequences of consonant-vowel-consonant appear as such in Hidatsa but appear in Crow with loss of vowel and a resulting consonant cluster (and with occasional metathesis). Hid. *sháaki*, Crow *ishtse* 'his hand'; Hid. *araaxishá-*, Crow *aráaxtia* 'not to know' (a few less well represented correspondences, as Hid. *sh*, Crow *t*, are not given in this paper).

With all these differences noted, why then should the extremely close affinity of Crow and Hidatsa have been stressed? No doubt because there also exist wide-spread identities between the two languages. Specifically, *p, w, r,* and some instances of *x, sh,* and *ts* are often the same in both languages, as *waaxapi-* 'I lie' (but the verb-final in Hidatsa would probably be different than that in Crow); *iríatsi-* 'to think'.

Some identities serve to establish Missouri River Siouan as a distinctive group rather than to indicate an especially recent dialect separation. Thus, as attested by both daughter languages, Missouri River Siouan differed from the other languages in not having nasalized vowels; in making a minimum use of sex gender in addressing persons (especially elaborate in Mandan); in having verb-finals of many shapes and functions, with zero least favored (while zero is either a favorite or the only verb-final in the other languages); in having as a reflex of proto-Siouan *-nk-* and *-ng-* only the stop with loss of the preceding *-n-* (while all other languages preserve some form of the cluster) (6).

Besides the systematic differences noted (1 to 7, above) which corroborate the interpretation of some distant separation of Crow from Hidatsa, there are also words in the two languages which show identities where the regular differences might be expected; these exceptional identities argue for secondary and more recent contacts which permitted borrowing (as Crow *waté*, Hid. *waataki* 'dish'; compare 1 and 2, above).

If there were more than two languages represented in the Missouri River group, dialect geography would be less dependent on the comparative method than it is under these limitations. A fuller roster of closely related languages is presented in the Mississippi Valley group. It was in part of this group that Dorsey did most of his comparative work. By his triliteral-quadriliteral rule he distinguished Iowa-Oto-Missouri (and other languages represented by three letter sequences) from Winnebago. But Mandan shares certain four letter sequences with Winnebago. We therefore place Mandan with Winnebago as a subgroup in contrast to Iowa-Oto-Missouri and the others. Whether this is an overly restricted application of the comparative method, or a lead for discovering an old connection between Winnebago and Mandan can be decided only after historically recent perspectives are gained and, as it were, discounted. We must lean upon dialect geography for gaining our historically recent perspectives.

[Since writing the above my attention has been called to an unpublished paper of Swanton's, privately distributed as part of the Indianapolis Archaeological Conference (1935), in which the author associates Tutelo and Biloxi and Ofo; in various published papers Swanton has associated Tutelo or Biloxi or Ofo, on the one hand, with Dakota, Chiwere, Crow, Hidatsa, Dhegiha, or Mandan on the other hand, that is, with all other Siouan languages except Catawba. I have used Swanton's isolation of Catawba as an example of the inspectional approach. But I cannot accept his other associations as examples of the inspectional approach. The others are listings of logical possibilities.]

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BACTERIOLOGY

Chairman: DONA GAYLOR GRAAM, Terre Haute

Dr. C. G. Culbertson, Indiana State Board of Health, was elected chairman of the Section for 1941.

ABSTRACTS

Malaria in Indiana. C. G. CULBERTSON, Indiana State Board of Health.—After a considerable period of time during which the state has been relatively free from malaria, there are indications of a gradual increase in various places over the state. While in general the endemic cases previously found in small numbers have been of the tertian variety, in the last few years estivoautumnal malaria has made its appearance. During the past summer routine examinations of blood clots made from patients clinically suspected of having typhoid or undulant fever has revealed about twenty cases in which plasmodia were demonstrated where the presence of the disease was at least not suspected from the information given on the specimen card. The thick smear method was employed in these determinations and three cases of estivoautumnal malaria were found among this group of twenty positive smears.

Rocky Mountain spotted fever. C. G. CULBERTSON and VERN K. HARVEY, Indiana State Board of Health.—This disease, due to a virus known as Rickettsia which is spread by wood ticks common throughout the state of Indiana has shown an increase each summer since 1926, until the summer of 1940 when there was a rather pronounced drop in its incidence over previous years. At first the cases were localized to the southern half of the state, being prevalent in Ripley and Dearborn counties. The first cases appeared in the middle western part of the state in Vigo and Montgomery counties. In the last two years cases have appeared in many scattered areas extending to the extreme northern part of the state. There is a universal history of exposure or bites of wood ticks in all cases. Measures for prevention of the disease must be directed toward protection of the individual by clothing, imunization, and daily inspection for the presence of ticks on the body. So far in Indiana the mortality from the disease has been about 50 per cent. No specific remedies are known.

Practical method in the control of malaria at Terre Haute. W. P. ALLYN, Indiana State Teachers College.—Studies were made of the breeding sites of mosquitoes within and about the city. The prevalence of the Culex and Anopholes groups of mosquitoes and their respective habitats were noted. Control was directed at the breeding sites of the mosquitoes. Shallow, swampy areas were sprayed periodically with a petroleum distillate. Ornamental pools, fish spawning areas, and the like were treated with a special larvicide, prepared with water-clear kerosene and

pyrethum extract emulsified in water with soap and dupinol in the presence of a defoamer. Cooperation of the citizens in the care of their own premises was solicited through the schools, Boy Scouts, radio, newspapers, civic organizations, and by direct contacts.

Antigenicity of Typhoid Vaccine Prepared from Cultures Grown at 30° C

H. M. POWELL and W. A. JAMIESON, Lilly Research Laboratories

We have had occasion to prepare typhoid vaccine from cultures grown at 30° C (lot B-5512A), and compare this with similar vaccine prepared from cultures grown at 37° C (lot B-5512B). The standard cultures used were Rawlings (No. 222) and Panama 58 (No. 228), and each lot of vaccine comprised 50 per cent of No. 222 and 50 per cent of No. 228. With the exception of use of 30° C incubation in the preparation of lot B-5512A, both vaccines were prepared as recommended for distribution for human use by the National Institute of Health.

Antigenicity of vaccines B-5512A and B-5512B was first tested by one dose immunization of rabbits (each animal receiving 2.5 billion organisms subcutaneously), and eight days later measuring the agglutinin titer of these rabbits. Table 1 shows the results of these tests conducted in the 55° C water bath. Stronger agglutinins were incited by vaccine prepared from cultures grown at 30° C than from cultures grown at 37° C.

These tests were then amplified to include the usual comparisons made in the 37° C water bath with serum from rabbits treated with National Institute of Health control vaccine. The results are shown in Table 2, and it appears that both experimental vaccines were fully equal in agglutinin production to the control vaccine, and both would have been deemed satisfactorily antigenic for human use (1). None of the rabbits used in these tests showed any agglutinins in a titer of 1-10 for either strain of typhoid bacilli before immunization.

Two groups of 20 mice each were then immunized with weekly subcutaneous doses of vaccines B-5512A and B-5512B; the first dose was 50 million, and second and third doses each were 100 million bacilli. This is equivalent to one-tenth of a human immunization. One week after the third dose of vaccine, subdivisions of these groups, along with a normal control group of mice, received decimal dilutions of pooled No. 222 and No. 228 living cultures in mucin as an immunity test (2). The results are shown in Table 3. It is observed that typhoid vaccine lot B-5512A prepared from cultures grown at 30° C produces definitely better active immunity against infection than regular typhoid vaccine lot B-5512B prepared from cultures grown at 37° C. For more exact end points of active immunity it is obvious that much larger groups of mice would be necessary.

Conclusions

The results of tests for agglutinin production in rabbits and active immunity in mice indicate that typhoid vaccine prepared from cultures grown at 30° C is better than similar vaccine prepared from cultures grown at 37° C in the regular way.

TABLE I.—Comparative Agglutination Tests of Sera of Rabbits Treated with Vaccine Prepared from Cultures Grown at 30° and 37° Centigrade Respectively

Vaccine Used	Resultant Rabbit Serum	Typhoid Agglutinogen	Serum Dilutions 1-320	1-640	1-1280	1-2560	1-5120	0
B-5512A (30° C)	6959	222	++++	++++	++++	+++	++	—
		228	++++	+++	+++	+	—	—
	6960	222	++++	++++	++++	+++	++	
		228	++++	+++	++	+	—	
	6961	222	++++	++++	++++	++++	+++	
		228	++++	++++	+++	++	+	
B-5512B (37° C)	6962	222	++++	+++	+++	+	—	
		228	++++	+++	+	+	—	
	6963	222	++++	++++	+++	+	—	
		228	++++	++	—	—	—	
	6964	222	++++	++++	+++	++	—	
		228	++++	+++	++	+	—	

Above readings made after incubation in 55° C. water bath one hour and standing overnight in icebox.

TABLE II.—Comparison of Agglutinin Production Using National Institute of Health Control Typhoid Vaccine as a Standard

Vaccine Used	Resultant Rabbit Serum	Typhoid Agglutinogen	Serum Dilutions 1-20	1-40	1-80	1-160	1-320	0
B-5512A (30° C)	6960	222	++++	++++	++++	++++	++++	—
		228	++++	++++	++++	++++	+++	—
	6961	222	++++	++++	++++	++++	++++	
		228	++++	++++	++++	++++	+++	
B-5512B (37° C)	6962	222	++++	++++	++++	++++	++++	
		228	++++	++++	+++	+++	++	
	6963	222	++++	++++	++++	++++	++++	
		228	++++	++++	+++	+++	++	
	6964	222	++++	++++	++++	++++	++++	
		228	++++	++++	++++	+++	+++	
National Institute of Health Lot 130	6265	222	++++	++++	++++	+++	++	
		228	++++	++++	+++	++	+	
	6266	222	++++	++++	++++	+++	+++	
		228	++++	+++	+++	++	+	
	6267	222	++++	++++	+++	+++	++	
		228	++++	+++	++	—	—	

Above readings made after incubation in 37° C. water bath one hour and standing overnight in icebox.
There was insufficient serum from rabbit 6959 shown in Table 1 to use in this test.

TABLE III.—Tests of Active Immunity of Typhoid Vaccines in Mice

Dose of pooled typhoid cultures 222 and 228 in mucin	Mice which received vaccine B-5512A	Mice which received vaccine B-5512B	Normal mice
10^{-2} cc.	D D D	D D D	D D D
10^{-3}	S S D	D D D	D D D
10^{-4}	S D D	D D D	D D D
10^{-5}	S S S	S S D	S D D
10^{-6}	S S S	S S D	S D D
10^{-7}	S S S	S S D	S D D
10^{-8}	S S	S D	S S D

S indicates survival of a mouse for 7 days.
D indicates death of a mouse within 7 days.

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A Malaria Epidemic of Terre Haute and Vicinity in 1938, 1939, 1940

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Introduction. The reappearance of malaria in epidemic form in Terre Haute and vicinity after an absence of half a century or more is of interest because: first, it has been spontaneous in its reappearance; second, it has persisted through the years 1938, 1939, and 1940; third, it has again reached as far north as Terre Haute after it has been confined to a more southern habitat.

Malaria probably has always been endemic in Terre Haute but for years it has been taught in hygiene classes in several colleges of the state that malaria had been exterminated from Indiana.

Brief History. The name of the city Terre Haute means high land because it is located on a high terrace on the east bank of the Wabash River. An Indian village was located on this terrace during early historic times before the white man settled in that region. The Indians found this location a healthful place compared to locations up or down the river or to locations across the river. When the white man came to the same region he also picked this comparatively healthful place to camp and later to live.

As the city increased in size and spread up and down the eastern bank and toward the level plains to the east, the white man began to encroach upon less healthful territory. The terrace is less pronounced as you travel a few city blocks north or south and the river may even overflow its banks into low lands where, when it recedes it may leave ponds, swamps, and pools of a more or less permanent nature. Toward the east, the prairie contained ponds, sluggish streams and swamps. By 1840-1850 this became an ideal place for the spread of the malarial parasite.

In conversing with W. O. Patton, age 90 years, I found that he recalls that in 1857 his family moved to Terre Haute from Ohio. Immediately upon arrival the whole family developed "chills" and "fever" which persisted for a period of three or four years. He recalls that everyone habitually took quinine by the teaspoonfuls, that people were often yellow in the late summer and fall and had to take greater quantities of quinine. As sewers were built and streams, ponds, and swamps were drained conditions improved so that by the turn of the century malaria definitely decreased and we know that it practically disappeared in the next few years.

The Epidemic of 1938, 1939, 1940. The estimated cases of malaria for 1938, 1939, 1940 were 1,084, 165, and 22, respectively.[1]

[1] I am indebted to E. T. Zaring, M.D., Secretary to the Terre Haute City Board of Health, for the estimated number of cases.

I feel sure that the number is underestimated rather than overestimated for it is a tradition for people to treat themselves with quinine for the "chills." The above estimate consists of the actual cases treated by physicians. However, only a fraction of the above was actually examined by means of blood smears, but a large enough sample was done to prove that the epidemic was actual and not imaginary. Fifteen to twenty blood smears, taken from as many different people, were stained with Wrights stain and examined. They were identified, by myself, and verified by Dr. L. T. Coggeshall, of the Rockefeller Foundation for Medical Research, as *Plasmodium vivax.* Three death certificates giving malaria as the cause of death were each followed up to see what the history of the cases were. The three cases were hospital cases. Two occurred this year (1940) and one last year (1939). I could find out little about the case last year except it was an old man.

Of the two cases occurring in 1940, one was a small boy two to four years of age and the other a woman of thirty-six years of age. Both cases were of short duration. The child upon being taken to the hospital was examined by the physician one day and died before he was seen the next day. The woman was a surgical case and was progressing well until two or three days after the operation she developed a very high temperature. The physician looked for post operative infection, even opened up the incision and found no pus. When a leucopenia was found and a blood smear examined the asexual schizont's were found in very large numbers. The patient died within thirty-six to forty-eight hours after the temperature began to climb. At one time the temperature reached 107° F. The patient died of cerebral symptoms. The physician says that the history of this case shows malaria the year before treated by a course of atabrine, and seeming recovery.

These three fatal cases may have been *Vivax falciparum,* and the malignancy of the disease would lead one to suspect it, but I was unable to get a blood smear for examination.

There were many typical and atypical cases. Many persons were inadequately treated and many self treated with proprietary remedies as well as quinine. Some strains of parasites were harder to kill than others and recurrences of the disease occurred the same year or succeeding years. A nurse who was treated two successive years by as many physicians, finally treated herself with large quantities of atabrine and plasmochin until she developed a splenitis, again took the disease the following year (1940), was treated by a third physician and is believed cured.

A druggist, inadequately treated with quinine, and who had several recurrences of the disease finally "cured" himself with plasmochin. Why this was so I do not know, for plasmochin is not a schizonticide.

A professor of Indiana State Teachers College, on the other hand, cured himself of a very severe case of "chills" by five days treatment with atabrine.

The medication as given by most physicians in Terre Haute is as follows:

Quinine—5 grains 4 times a day. Total 20 grains daily for five days.

Atabrine—1½ grains 3 times a day for five days.

Atabrine or quinine taken for five days followed by plasmochin ⅓ grain three times a day for five days.

For the benefit of those who do not know the new snythesized drugs mentioned, I will briefly explain:

Quinine—derived from cinchona bark, usually a sulphate salt, a schizonticide.[2]

Atabrine—a synthetic dye and a schizonticide.

Plasmochin—a synthetic drug and a gametocide.

Rhodoquine—a French product and a homologue of plasmochin.

Conditions Leading Up to the Epidemic. In 1938 the stage seems to have been well set for an epidemic of malaria. In the first place the rainfall in the spring and summer of 1938 was very heavy. The U. S. Weather Bureau located in Terre Haute gives the total rainfall for the months of June, July, August and September of 1938, 1939, and 1940 as in Table 1.

TABLE I.

	1938	1939	1940
June	4.32 inches	6.16 inches	2.99 inches
July	4.86 inches	4.38 inches	2.25 inches
August	10.03 inches	3.57 inches	2.72 inches
September	1.50 inches	1.17 inches	.96 inches
Total	20.71 inches	15.28 inches	8.92 inches

Furthermore, the flood stage of the river occurred many times during 1938, and fewer times in 1939, lasting several days or weeks each time. I did not analyze this factor completely except to note that peaks of the floods were reached on the dates as set out in Table 2. The flood stage of the river is 14 feet.

TABLE II.

1938		1939		1940	
Feb. 21	14.6 ft.	Feb. 21	14.0 ft.	Never reached flood stage	
Feb. 25	15.7 ft.	Feb. 26	16.5 ft.		
Mar. 17.	14.5 ft.	Mar. 16-22	24.8 ft.	Highest point	
Mar. 22.	17.5 ft.			Mar.	13.1 ft.
Apr. 13	21.7 ft.	Apr. 22	22.0 ft.	Apr.	11.9 ft.
July 1-9	20.7 ft.	June 20	14.1 ft.		

NOTE: Flood stage of Wabash River at Terre Haute is 14 feet.

There is much seepage of water below the 14-foot stage and much backwater at the flood stage. See Table 2. There are large natural basins for this water west of the river and a few places even east of the river.

[2] It is interesting and alarming to note in this respect that the United States is importing large quantities of quinine from Dutch West Indies and if war comes in the Pacific the problem of malaria may become a serious one in Indiana as well as in the rest of the United States.

These basins serve as natural breeding places for mosquitoes. The prevailing westerly winds or an unusual north wind would blow mosquitoes, if present, toward the city.

In the second place, it is worth observing that a fad for fishpools and rock gardens reached a peak during the year 1938, so that more places were present for mosquito breeding.

Furthermore, it had been a matter of observation and comment and can be taken for what it is worth that the U. S. Government began the building of levees along the river which may or may not be a hindrance to drainage of surface water, seepage and overflow of levees which occurred in 1938 near West Terre Haute.

No doubt, also, new strains of malaria were brought in by human hosts. Travelers to Florida could and did, as I know specifically, return with malaria. It is also a matter of conjecture that inadequately treated paresis cases treated with malaria may have spread the disease.

Summary

1. Terre Haute and vicinity suffered a spontaneous malaria epidemic of fair magnitude during the years 1938, 1939, 1940.

2. A survey of the laboratories and physicians showed that more than a thousand cases occurred in 1938 at the peak of the epidemic.

3. Three deaths occurred during the epidemic and were of a cerebral type. Blood smears of these cases were not seen by the author and so were not specifically identified—probably due to malignant form *Plasmodium falciparum*.

4. Fifteen or twenty blood smears examined by the author and verified by the Rockefeller Foundation for Medical Research were identified as *Plasmodium vivax*.

5. The mosquito involved was the common *Anopheles quadrimaculatus*; further work may disclose the presence of other species.

6. Heavy rainfall of 1938 and 1939 plus decreased drainage and increased number of artificial pools made perfect conditions for the increased breeding of mosquitoes.

7. Human carriers of malaria have brought malaria from the Southern States to Indiana. It is also probable that persons treated for paresis by malaria and inadequately treated for the latter disease spread malaria.

The Complement Fixation Reaction as a Diagnositic Aid in Malaria

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The need for an improved method of diagnosis is recognized as one of the outstanding essentials in malaria. There is no disease more readily diagnosed than malaria during the acute stage when there are circulating parasites, but unfortunately this stage lasts a very short time. The chief difficulty is encountered in the chronic stage of the disease when the clinical symptoms are vague and when it is practically impossible to detect the parasites in the blood smears. The belief that chronic infections may persist for many years has been substantiated repeatedly by the transmission of malaria following blood transfusions from donors who had their initial attack of malaria as long as 25 years previously. Other than the recognition of the parasite in the blood smear there is no accurate diagnostic procedure, and the negative blood smear has little value in this disease.

The complement fixation reaction as used in many diseases has been tried in malaria with little success. The chief difficulty was the lack of a satisfactory source of parasites for an antigen. Since it is not possible artificially to cultivate the malaria parasite, early investigators had to depend upon infected whole blood or placentas from infected mothers for their supply of parasites. Their results demonstrated important possibilities for the test, but the lack of a standard satisfactory antigen prohibited its trial as a diagnostic aid.

In our laboratories it has been discovered that a malaria infection highly virulent for the rhesus monkey furnishes abundant quantities of antigen that binds complement in the serum of patients with chronic infections of either vivax or falciparum malaria (1, 2). The test is specific, and the technique is essentially the same as that of the ordinary Wassermann test.

Antigen. The antigen was made from parasitized red cells obtained from rhesus monkeys after infection with *Plasmodium knowlesi*, a natural parasite of cynomolgus monkeys which has a similar morphological appearance to some of the human strains of malaria. This parasite produces an overwhelming infection, and the blood is obtained shortly before the expected death of the animal when approximately 50 per cent of the red cells are infected. The red cells are then washed free from the serum and preserved by freezing and drying in 5 cc. amounts.

Method of Performing the Test. The stored antigen was rehydrated and diluted 1:100 in normal saline. This was well beyond the anticomplementary range and yet highly antigenic. The tests were set up like the ordinary Wassermann test, employing 2 units of complement with

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a sheep cell system. The experimental sera in this study were obtained from patients with induced vivax and falciparum malaria induced for therapeutic purposes, and the controls were sera from normal individuals, from patients with strongly positive Wassermann reactions, and a large number of sera from patients with different infectious diseases as lobar pneumonia, yellow fever, lymphocytic choriomeningitis, etc. Antigen controls were normal monkey red cells.

Specificity of the Test. It was found that the serum of patients with vivax and falciparum malaria would fix complement with the monkey parasite antigen in approximately the same dilutions as the serum from patients with *P. knowlesi* malaria, which was administered for the treatment of general paresis. This was an indication that the antigen was broad in its antigenic power, a useful characteristic because it is readily obtained and easily prepared yet just as capable of reacting with heterologous as with homologous malaria serum. That the positive reactions were specific and caused by the malaria infections alone was proved by the fact that negative tests before the acute attack became positive during convalescence. The serum of individuals with positive Wassermann tests was negative in the absence of malaria and positive only when a malaria infection was present. The sera obtained from patients with acute infectious diseases or from animals with blood stream protozoal infections such as trypanosomiasis or piroplasmosis gave negative tests.

Relationship of the Complement Fixation Test to Presence of Circulating Parasites. As mentioned earlier, the usefulness of this test as a diagnostic procedure depended entirely upon its being positive when it was not possible to detect parasites in stained thick or thin blood smears. Accordingly, serum was obtained from a group of twelve patients with general paresis, and they were inoculated with vivax malaria. They were then bled at 10-day intervals, and in addition their blood was examined daily for parasites. After parasites were no longer found serum specimens were obtained until the malaria complement fixation test became negative. The results of this investigation revealed that complement-fixing antibodies appeared in the serum shortly before the peak of the malaria infection or about 2 weeks after the onset of clinical symptoms and persisted for approximately 5 months after the disappearance of circulating parasites. This finding is given added significance when it is realized that the particular strain of malaria plasmodium employed in this study does not produce a long, drawn out chronic infection as is the characteristic behavior of many other strains of the same organism. Presumably serum obtained from individuals in areas of endemic malaria where chronic infections are prevalent should yield positive results for even longer periods of time than was obtained in the case of the mild therapeutic infections.

Summary

A complement fixation test has been devised as an aid to the diagnosis of chronic malaria infections. The antigen for this test is prepared from red cells infected with *Plasmodium knowlesi*, a monkey malaria

parasite which will fix complement in human malaria serum. The test is specific for malaria and has not been found to be influenced by the presence of luetic complement-fixing antibodies. In induced therapeutic malaria infections the test becomes positive about the second week of infection and persists for approximately 5 months after it is no longer possible to detect parasites in the blood smears. The final evaluation must come from studies in the field where malaria is endemic, although the experimental studies thus far suggest that the test may have considerable merit.

Bibliography

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BOTANY

Chairman: RALPH M. KRIEBEL, Bedford

R. E. Cleland, Indiana University, was elected chairman of the section for 1941.

ABSTRACTS

A biotic view of Indiana. RALPH M. KRIEBEL, Bedford.—Indiana is examined as a biological unit. Consideration is given to the physiographic and ecologic areas with their varying conditions of topography, soil, water, plants, and animals. Attention is directed to the individual characteristics of factors which may be independent of one another, yet unite to form a higher unity, an organism. It is pointed out that the biological possibilities of Indiana have already been overstepped by the exploitation of resources, agricultural practices, and socio-economic enterprises. Changes which have come about in plant and animal communities and in soils are reviewed. Special reference is made to some biological features concerning the flora. Methods of achieving and developing biological unity are suggested. New alignments of extension and teaching are discussed.

A contribution to the taxonomic study of the algae of Indiana. HELEN H. WELCH, Wood Junior College, Mathiston, Mississippi.—This paper is a taxonomic study of the algae of Indiana. The writer reports one genus, seventeen species, and one variety which have not been previously reported for Indiana. The writer also reports thirty not previously reported algal forms for Vigo County. These include one genus, twenty-eight species, and one variety.

Pollen spectra from three bogs on the Gillen Nature Preserve along the Michigan-Wisconsin state line. J. E. POTZGER, Butler University.—The three bogs included in the study were located along the Michigan-Wisconsin state line where Vilas County, Wisconsin, and Gogebic County, Michigan, adjoin. The forest succession was from a spruce-fir or spruce-fir-pine dominance to a sudden pine dominance (within one foot-level). This gradually changed to a pine-hemlock-birch dominance of which oak became an associate in the topmost layers. The early succession was similar to that in areas of Late Wisconsin glaciation in Indiana, but pine has declined but little in Wisconsin since it succeeded spruce and fir, while in Indiana oak has dominated for a period during which more than half of the sediments in the bogs were being deposited. The study is from the Limnological Laboratory of the Wisconsin Geological and Natural History Survey of 1940.

Studies on the viability of Liriodendron seed. ARTHUR T. GUARD, Purdue University.—A study has been made to determine whether there were any facts which could be established that would have bearing on seed collection with respect to the number of viable seed harvested. The

low viability is due in a very large measure to the absence of embryos in the samaras. Studies were made of the per cent of good seed on different trees and at various levels on the same tree. Studies were also made in regard to the difference in good seed at the base, middle and tip of individual cones. More good seed are found in the middle part of the cone. Trees varied widely in the per cent of good seed produced.

Fungus development as affected by carbon and nitrogen sources. CHARLEY L. PORTER, Purdue University.—Fungi of several species including *Diplodia zeae* were grown on a basic medium consisting of magnesium sulphate, ammonium nitrate, dihydrogen potassium phosphate, and a source of carbon. All media were sterilized in a DeKhotinsky water bath at 68° C. on three consecutive days. Dextrin and inulin were found to be the most satisfactory sources of carbon. Urea, nucleic acid, and cystine were satisfactory sources of nitrogen.

Symptoms of mineral deficiency in pine. CLINTON H. HOBBS, Purdue University.—Two species of pine were grown from seed in nutrient sand cultures from which various essential elements were excluded. Deficiency symptoms for nitrogen, phosphorus, and potassium were obtained in four to six weeks, and for magnesium in three months.

Dendrographic studies on the beech, *Fagus grandifolia* Ehrh., for 1940. RAY C. FRIESNER, Butler University.—One dendrograph and two dendrometers attached one each to three trees on April 1, 1940, showed elongation of radii to begin during the week ending May 13. This coincided with the time of full expansion of the leaves. Growth continued with increasing intensity until June 17 and with decreasing intensity until July 15, after which the radii showed losses for most of the weeks but with some recoveries following rains. At the close of the observation period (October 15) recovery was nearly complete. Total increase in radii ranged from 0.928 mm. to 0.970 mm. Daily reversible variations showed the radii to be longest between 4 and 7 a.m. and shortest between 4 and 6 p.m. The extent of change in length of radii during daily variations varied from 0 during the week ending April 8, to 0.22 mm. during the weeks ending July 29 and August 5.

Relation of annular ring formation to rainfall as illustrated in six species of trees in Marshall County, Indiana. RAY C. FRIESNER and GLADYS M. FRIESNER, Butler University.—Microscopic measurements of year ring growth were made for the years 1900-1939 inclusive from eight radii from each of seventeen sections of *Quercus borealis maxima* (Marsh) Ashe; 4 sections of *Q. alba* E.; 6 of *Fraxinus americana* L.; 2 of *Acer saccharum* Marsh. and 1 each of *Carya cordiformis* (Wang.) K. Koch and *Liriodendron tulipifera* L. Three trees of *Q. borealis maxima* showed highest correlation (63, 66 and 83%) between radial growth and rainfall for the calendar year; 3 showed highest correlation (75, 80, 86%) with rainfall for the vegetative year, viz. November to October; 4 showed highest correlation (71, 75, 77, 81%) with rainfall for May to August; 4 showed highest correlation (54, 62, 63, 67%) with rainfall for June; and 1 showed highest correlation (71%) with rainfall for June to August. All four trees of *Q. alba* showed a strong correlation (68 to 77%) with the rainfall

for June but three of them also show a similar correlation with rainfall for June to August and the same three show nearly as high a correlation (67 to 76%) with rainfall for May to August. One tree shows the highest correlation for the species (79%) with rainfall for November to October. All specimens of *Fraxinus americana* show high correlation (68 to 80%) with rainfall for either May to August or June to August. One specimen of *Acer saccharum* showed highest correlation (70%) with rainfall for June and the other showed highest correlation (81%) with rainfall for May to August. *Carya cordiformis* shows highest correlation (69%) with rainfall for June and *Liriodendron tulipifera* shows highest correlation (89%) with rainfall for the calendar year. However, the last species also shows 71 and 74% correlation, respectively, for May to August and June to August.

A technique for the study of the respiration of excised corn roots under asceptic conditions. RAYMOND E. GIRTON. Purdue University.—Corn grains were sterilized in sodium hypochlorite solution and germinated on sterile agar at room temperature. After germination, the roots were cut off asceptically and transferred to nutrient solutions in sterile respiration chambers. Moist carbon-dioxide-free air was led into each respiration chamber through a sterile cotton filter to prevent the entrance of micro-organisms. Upon leaving the respiration chamber, the air again passed through a sterile cotton filter which served as an additional protection against contamination. Respiratory activity was determined by absorption of the respired carbon dioxide in alkali which was then titrated. By this means it was possible to obtain continuous records of carbon dioxide production from sets of 50 sterile roots each for periods of 100 hours or longer.

Kodochromes of some spring flowers of the San Francisco Bay region. RAYMOND E. GIRTON, Purdue University.—This set of twenty-four slides represents some of the common wild flowers of the Berkeley hills and Mount Tamalpais region. Four of the slides are of rhododendrons under cultivation in the San Francisco Golden Gate Park.

Microphotography as an aid in the identification of pollen grains. HOWARD R. YOUSE, DePauw University.—The importance of the identification of pollen grains to botanists, geologists, entomologists, horticulturists, and medical men makes the above study very essential. The present limitations and future possibilities of microphotography as an aid in the identification of pollen grains was discussed.

Some algae, fungi, and hepaticae previously unreported from Indiana. FLOYD S. SHUTTLEWORTH, Indiana University.—Algae being reported for the first time from Indiana are *Symploca muscorum* and *Phacotus lenticularis*. The latter, a bivalved unicellular member of the Volvocales, has previously been reported from Iowa, California, and Lake Erie in this country and from Europe. Among the Ascomycetes being reported for the first time are *Catinella nigro-olivacea* and *Coryne urnalis*. The liverwort *Blasia pusilla* was found to be abundant near Trevlac, Brown County. This is the first report of this genus from the state. Notes on

the distribution and morphological features concerning each species are given.

A Rare Myxophycean, *Lyngbya purpurea* Gomont, at Richmond, Indiana. LAWRENCE J. KING, University of Chicago.—*Lyngbya purpurea* Gomont, a species very rarely found, is now reported for the first time for North America. The species is quite sharply defined because of its color and its small size. The only other published records are for Kerguelen's Land in Antartica by J. D. Hooker in 1845, and for Tanganyika Sea in Africa by G. S. West in 1907. The only North American station known for it to date is in the spray pond of an ice company at Richmond. Associated species of Myxophyceae found in the pond are also listed.

Studies in Indiana Bryophytes III

WINONA H. WELCH, DePauw University

The mosses used in this study are Indiana collections in herbaria in the following institutions: Indiana University, Butler University, DePauw University, Field Museum of Natural History, University of Illinois, and University of Chicago; and the personal herbaria of the following: Charles C. Deam, J. P. Naylor, and the author. The collections presented to the author by Charles C. Deam, R. M. Kriebel, William D. Gray, Earl L. Harger, Jr., R. V. Drexler, and Dorothy Parker have contributed considerably to the range of distribution.

The nomenclature is that of A. J. Grout, The Moss Flora of North America North of Mexico 1:148-192. 1938; 193-246. 1939.

The distribution of each species is based largely upon Indiana specimens examined by the author and is shown by the list of counties in which collected. The asterisk preceding the name of a county indicates that the species has been reported from that locality according to published records but not studied by the author.

The asterisk following the name of a species or a variety is an indication that, according to available literature, this is the first published record for Indiana.

The author's collections of bryophytes from May, 1937, to August, 1939, were made with the financial assistance of an Indiana Academy of Science research grant through the American Association for the Advancement of Science, and those since June, 1940, by the aid of a research grant from the Graduate Council of DePauw University. I wish this acknowledgment to express my sincere appreciation of this assistance.

POTTIACEAE

(Tortulaceae of Mosses with Hand-lens and Microscope, A. J. Grout, 1903.)

Plants small to large (2 mm. to 10 cm. high); usually in sods or tufts; leaves strongly costate; upper leaf cells usually small, thick-walled, and more or less papillose, the basal leaf cells usually thin-walled and hyaline; capsules usually peristomate, but also cleistocarpous and gymnostomous, immersed to exserted on a long seta; peristome when present consists of 16 or 32 teeth, papillose, sometimes filiform, entire or cleft, sometimes to base, straight or twisted, often united at base into a tube.

1. Leaves narrowly lanceolate to oblong, wider below than above, (*Trichostomeae*) 2
   Leaves broadly ovate or oblong, lingulate or spatulate, wider above than below, (*Pottieae*) 8
2. Plants up to 10 mm. high 3
   Plants up to 10 cm. high but usually shorter 5

3. Plants up to approximately 5 mm. high; leaves strongly crisped when dry; leaf margins strongly involute 4
Plants up to 10 mm. high; leaves not crisped when dry but ± contorted and appressed; leaf margins plane .... *Gymnostomum calcareum*
4. Plants dull-green; leaves keeled; capsules immersed .... *Astomum*
Plants yellowish-green; leaves not keeled; capsules exserted on seta 3-7 mm. long .... *Weisia*
5. Leaves curled-crispate when dry; bases whitish and glossy; costa excurrent in a mucro .... *Tortella*
Leaves ± contorted when dry but usually not curled-crispate 6
6. Leaves appressed and ± contorted when dry 7
Leaves not appressed when dry, keeled, lanceolate-acuminate, acute; upper leaf cells distinct .... *Gymnostomum recurvirostrum*
7. Apices generally obtuse; costa excurrent as a short yellow mucro .... *Barbula unguiculata*
Apices acute or subacute; costa disappears in the apex ... *Barbula fallax*
8. Plants bulbiform, subglobose, approximately 2 mm. high when mature .... *Acaulon rufescens*
Plants not bulbiform 9
9. Leaves with costa densely spinose-papillose on back and excurrent into a sharply-serrated awn 1-3 mm. long .... *Tortula ruralis*
Leaves not as above 10
10. Plants 1-3 mm. high: leaves acute, older ones with an evident band of 2-3 rows of lighter colored and less densely papillose cells .... *Desmatodon*
Plants up to 5 mm. high; leaves not bordered as above 11
11. Plants 1-2 mm. high; leaves ovate to oblong-lanceolate, acuminate; costa long excurrent, often colorless at apex; capsules ± immersed *Phascum*
Plants usually 3-5 mm. high, sometimes up to 1 cm.; leaves lanceolate to ± spatulate, acuminate to acute; costa usually excurrent into a stout, yellowish to brown awn; capsules exserted on setae 2-6.5 mm. long .... *Pottia*

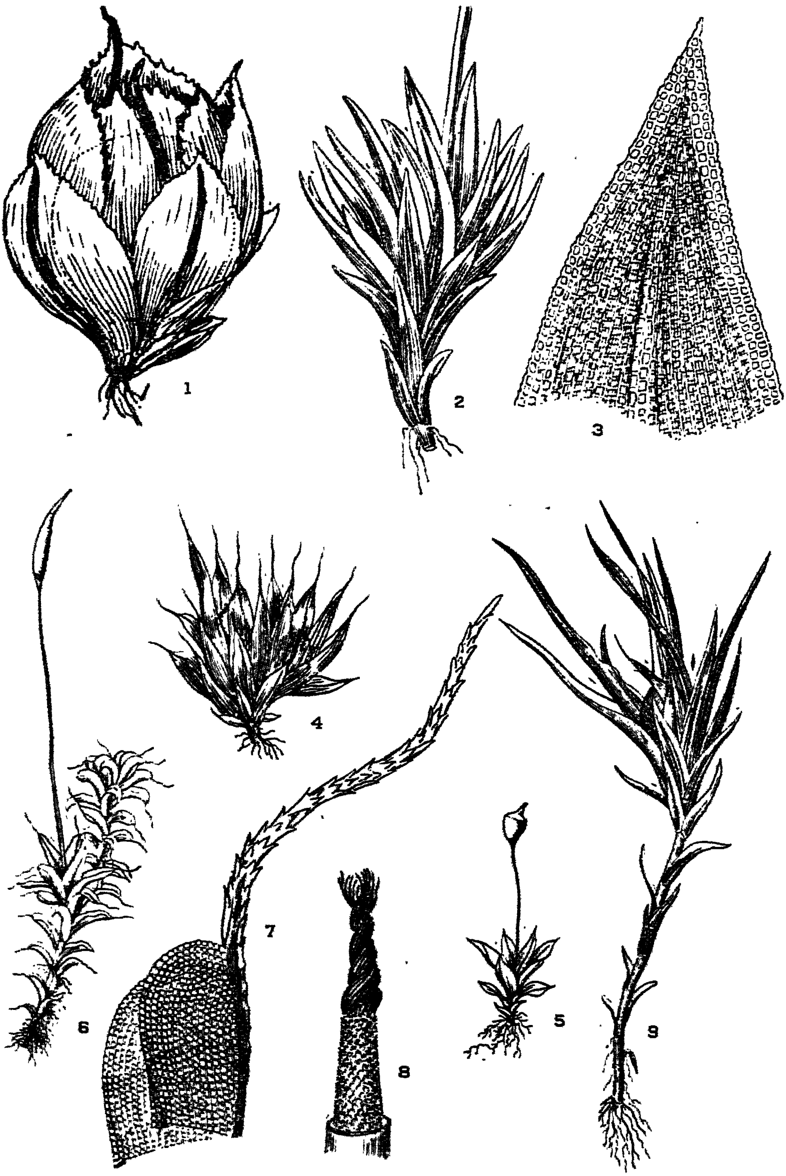
POTTIEAE

Acaulon

A. rufescens Jaeg.* (Fig. 1.) Plants minute, up to 2 mm. high when mature, bulbiform, subglobose; leaves not papillose, lower minute, upper much larger, very concave, boat-shaped, enclosing the capsule, costa ± percurrent to excurrent into a squarrose-recurved apiculus; capsule immersed, ± spherical or with a minute apiculus; mature spores 40-50μ in diameter, smooth, maturing in winter to early spring. On bare, moist soil; Putnam County.

Desmatodon

D. Porteri James. (Figs. 2, 3.) Plants small, gametophytes 1-3 mm. high; leaves up to 2 mm. long, oblong-lanceolate to ovate-lanceolate, acute; leaf margins entire, those of older leaves with evident border of 2-3 rows of lighter colored and less densely papillose cells; costa stout, almost percurrent; seta 7-10 mm. long; capsule cylindric, urn about 2 mm. long; annulus persistent, large, and conspicuous; peristome papillose, teeth irregularly divided into two or three forks, these sometimes united; spores smooth, about 8μ in diameter, mature in early spring. On limestone rocks; Decatur, Gibson, Jefferson, Jennings, Lawrence, Martin, Monroe, Owen, Parke, Perry, Putnam, Sullivan, and Warren Counties.



All figures (with the exception of Fig. 21, which is original), are copied, with permission, from A. J. Grout, Mosses with Hand-lens and Microscope (M.H.M.), and Moss Flora of North America North of Mexico (M.F.). (The figures in parentheses refer to these books.) *Acaulon rufescens* (M.F., pl. 91). Fig. 1. Gametophyte and sporophyte, x 25. *Desmatodon Porteri* (M.H.M., fig. 79). Fig. 2. Gametophyte, enlarged. Fig. 3. Apex of old leaf, showing characteristic border cells, enlarged. *Phascum cuspidatum*, var. *americanum* (M.H.M., Fig. 68,

Phascum

P. cuspidatum [Schreb.] Hedw.,* var. **americanum** Ren. & Card.* (Fig. 4.) Gametophytes usually 1-2 mm. high; upper leaves ovate to oblong-lanceolate, acuminate, keeled, about 2 mm. long, upper cells hexagonal, rhomboidal, or subquadrate, finely papillose; costa long excurrent; capsules ovoid-globose, about 1 mm. long, immersed or nearly so, cleistocarpous; spores 24-35μ in diameter, mature in spring. On bare soil of banks, old fields, and pastures; Delaware and Putnam Counties.

Pottia

P. truncata (Hedw.) Fürnrohr. (Fig. 5.) Gametophytes usually 3-5 mm. high, sometimes up to 10 mm.; upper leaves lanceolate to spatulate, 1-2.5 mm. long, acuminate to acute; upper leaf cells smooth to very slightly papillose on lower surface; costa strong, yellowish to reddish brown, commonly excurrent into a smooth, stout, yellowish to brown awn; urn gymnostomous, obovate with operculum attached, truncate and wide-mouthed after operculum falls, up to 1 mm. long and 0.8 mm. in diameter, neck short and $\pm$ indistinct, annulus persistent; seta 2-6.5 mm. long, reddish-yellow; spores reddish-brown to brown, finely papillose, 23-30μ in diameter, mature from late autumn to spring. On moist soil in grasslands and along streams, and on stone walls; Monroe, Putnam, and *Tippecanoe Counties.

Tortula

T. ruralis (Hedw.) Smith.* (Figs. 6-8.) Plants 2-8 cm. high; leaves $\pm$ twisted when dry and squarrose-recurved when moist, 3-7 mm. long including awn, obtuse, truncate, or emarginate at apex, keeled; costa red or brown, densely spinose-papillose on the back, excurrent into a long (1-3 mm.), serrate awn; upper leaf cells densely papillose; seta red, 1-3 cm. long; capsule long-cylindric, urn 3-5 mm. long; annulus persistent; peristome with a checkerboard-like basal tube, teeth papillose, twisted at least twice; spores brownish, slightly granulose, 10-14μ in diameter, maturing in spring. On soil and rock, frequently calcareous substrata; Porter County.

TRICHOSTOMEAE

Astomum

A. Muhlenbergianum (Sw.) Grout.* (Fig. 9.) Plants approximately 5 mm. high; leaves strongly crisped when dry, spreading when moist, larger ones up to 3 mm. long, strongly involute to subtubular above; costa strong, excurrent into a short mucro; upper leaf cells quadrate or

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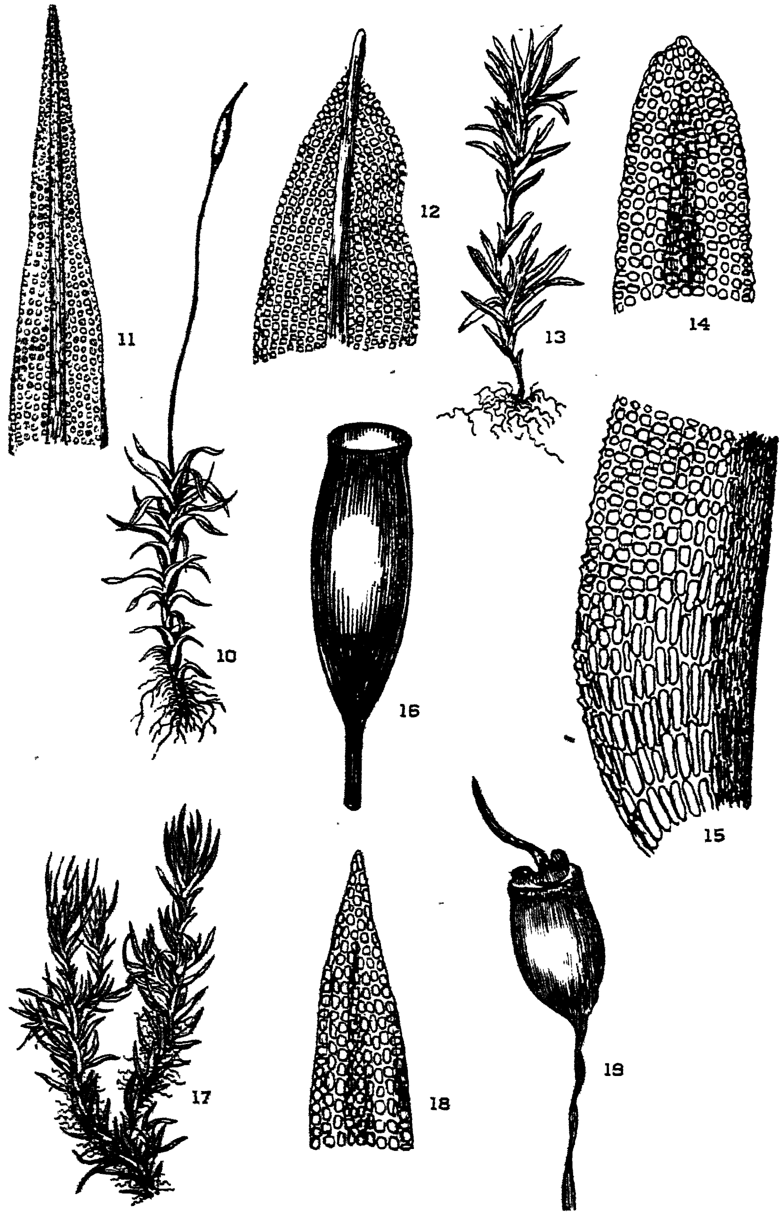
as var. *piliferum*). Fig. 4. Gametophyte and sporophytes, enlarged. *Pottia truncata* (M.H.M., pl. 33). Fig. 5. Gametophyte and sporophyte, enlarged. *Tortula ruralis* (M.H.M., pl. 35). Fig. 6. Gametophyte and sporophyte, enlarged. Fig. 7. Apex of leaf and serrate excurrent costa, enlarged. Fig. 8. Tessellate peristome, enlarged. *Astomum Muhlenbergianum* (M.F., pl. 77). Fig. 9. Gametophyte and sporophyte, enlarged.



Barbula fallax (M.H.M., pl. 29). Fig. 10. Gametophyte and sporophyte, enlarged. Fig. 11. Leaf apex, enlarged. *Barbula unguiculata* (M.H.M., Fig. 72). Fig. 12. Leaf apex, enlarged. *Gymnostomum calcareum* (M.H.M., pl. 26). Fig. 13. Gametophyte, enlarged. Fig. 14. Leaf apex, enlarged. Fig. 15. Portion of leaf base, showing rectangular cells along midrib, enlarged. Fig. 16. Urn, enlarged. *Gymnostomum recurvirostrum* (M.H.M., pl. 24). Fig. 17. Gametophyte, enlarged. Fig. 18. Leaf apex, enlarged. Fig. 19. Capsule, enlarged.

hexagonal, densely papillose; seta much shorter than the capsule; capsule elongate-spherical, about 0.4 mm. in diameter, apiculate; spores 20-30μ in diameter, strongly papillose, mature in early spring. On soil in old fields and in moist grassy spots; Putnam County.

Barbula

1. Leaves ± obtuse at apex, costa usually excurrent as a pellucid mucro .... *B. unguiculata*
   Leaves ± acute at apex, costa disappearing in apex, never mucronate *B. fallax*

B. Fallax Hedw. (Figs. 10, 11.) Plants 1-3 cm. high; leaves appressed, closely imbricated and slightly twisted when dry, wide-spreading to recurved when moist, lanceolate, 1.5-2.5 mm. long, gradually tapering to a ± acute apex, keeled; margins revolute to above the middle; costa strong, disappearing in the apex; upper leaf cells obscure, densely papillose; seta red, 1-1.5 cm. long; capsule elongate-ovoid to subcylindric; peristome long and much twisted; spores smooth, mature from late autumn to early spring. On moist bare soil, rocks, and walls, frequently on calcareous substrata; Monroe and *Wayne Counties.

B. unguiculata Hedw. (Fig. 12.) Plants usually less than 2 cm. high; leaves appressed and variously contorted when dry, erect-spreading and recurved to ± squarrose when moist, oblong to tongue-shaped, apex generally obtuse; costa strong, very papillose on the back, excurrent as a short, yellow mucro; margins recurved in lower half, plane above; upper leaf cells quadrate or rounded, densely papillose, obscure; seta 0.5-2.5 cm. long, deep red; capsule cylindric; the 16 peristome teeth papillose, twisted in at least two complete spiral turns, divided into 32 filiform divisions, spores ± smooth, 9-12μ in diameter, mature from winter to early spring. On moist soil in fields, old paths, roadside banks, stones, and walls, frequently on calcareous substrata; Cass, Decatur, Henry, Jasper, Jefferson, Jennings, Knox, Lake, Lawrence, Marion, Martin, Monroe, Parke, Perry, Posey, Putnam, Sullivan, Tippecanoe, Warren, and *Wayne Counties.

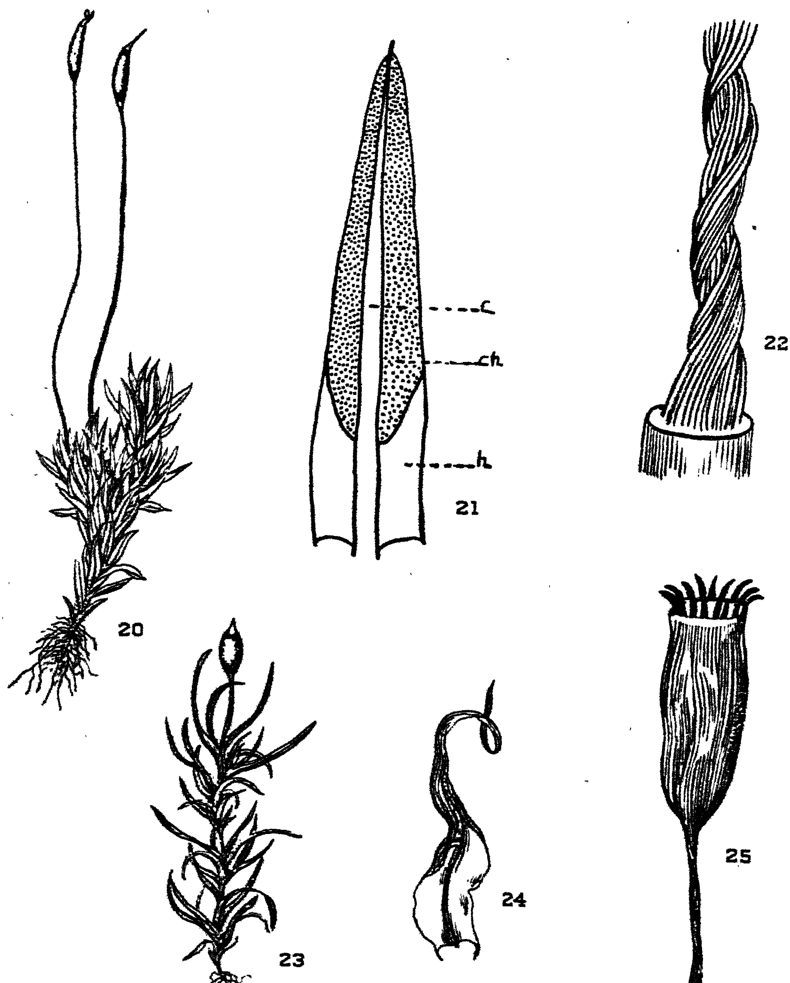
Gymnostomum

1. Gametophytes up to 10 mm. high; leaf margins plane; upper leaf cells densely papillose and obscure; basal cells smooth, pellucid, those near the costa rectangular, others ± quadrate; seta 3-5 mm. long; spores 8-10μ in diameter .... *G. calcareum*
   Gametophytes up to 10 cm. in length but usually shorter; leaves keeled, with one or both margins recurved below; upper leaf cells distinct; basal cells elongate-rectangular; seta 8-10 mm. long; spores 15-22μ in diameter .... *G. recurvirostrum*

G. calcareum Nees & Hornsch. (Figs. 13-16.) Gametophytes 1-10 mm. high; leaves ± contorted and appressed when dry, scarcely crisped, about 1 mm. long, usually lanceolate with ± acute apices; upper leaf cells densely papillose and obscure; basal cells ± quadrate except those near the costa rectangular, smooth, and pellucid; costa strong, disappearing below apex; seta 3-5 mm. long; capsule oblong, obovoid, or cylindric, usually ± narrowed at mouth when dry and empty; peristome and

annulus lacking; spores 8-10μ in diameter, mature in summer. On moist rocks $\pm$ calcareous; Jefferson, Jennings, Lawrence, Madison, Martin, Montgomery, Owen, Parke, Putnam, Sullivan, and Washington Counties.

G. recurvirostrum Hedw. (Figs. 17-19.) Plants in soft, thick sods, bright-green to yellowish-green above, darker and reddish below, up to 10 cm. in length but usually shorter; leaves only slightly contorted when dry,



Tortella caespitosa (M.H.M., pl. 32). Fig. 20. Gametophyte and sporophytes, enlarged. Fig. 21. Diagram of leaf to show V-shaped area of hyaline cells, *c*, costa, *ch*, chlorophyllose cells, and *h*, hyaline cells. Fig. 22. Peristome, enlarged. *Weisia viridula* (M.H.M., pl. 23). Fig. 23. Gametophyte and sporophyte, enlarged. Fig. 24. Leaf, showing strongly involute margins, enlarged. Fig. 25. Urn and peristome, enlarged.

erect to erect-spreading when moist, 1-1.5 mm. long, lanceolate, keeled, acute at apex; one or both margins recurved below; upper leaf cells distinct, rounded, ± quadrate, or rectangular; costa strong, disappearing below apex; seta 8-10 mm. long; capsule dark red-brown, ovoid to ± spherical, about 1 mm. long, widest at mouth when dry and empty; peristome lacking; operculum remains attached to columella after dehiscence; spores 15-22μ in diameter; mature in late summer to autumn. On moist cliffs, especially those ± calcareous; Fountain, Jefferson, Jennings, Lawrence, Montgomery, Owen, Parke, Putnam, Sullivan, Washington, and *Wayne Counties.

Tortella

T. caespitosa (Schwaegr.) Limpr. (Figs. 20-22.) Gametophytes up to 1.3 cm. high; leaves crisped when dry, ± spreading when moist, ± lanceolate, acuminate to ± mucronate at apex, 1.5-4.5 mm. long; costa yellow, usually excurrent in a mucro; upper leaf cells quadrate, papillose, lower leaf cells rectangular, hyaline, extending obliquely higher up the margin than at the costa, terminating in a V-shaped line; seta red at base to pale yellow-green above, about 1.5 cm. long; capsule cylindrical, 1.5-2.5 mm. long; peristome teeth 32, papillose, filiform, twisted two or three times; spores greenish, translucent, ± smooth, 7-11μ in diameter, mature in spring. In woods, on rock, base of tree trunks, decaying wood, and soil; Cass, Clark, Crawford, Dubois, Harrison, Jackson, Jasper, Jefferson, Jennings, Lake, Lawrence, Madison, Martin, Monroe, Montgomery, Owen, Parke, Perry, Porter, Posey, Putnam, *Scott, Spencer, Steuben, Washington, and *Wayne Counties.

Weisia

W. viridula Hedw. (Figs. 23-25.) Gametophytes bright-green to yellowish-green, up to about 5 mm. in height; leaves crispate when dry, erect-spreading when moist, upper about 3 mm. long, lanceolate, acute to acuminate; margins strongly involute above, often plane near the base; costa strong, excurrent into a sharp, ± hyaline point; upper leaf cells round to hexagonal, papillose, obscure; seta yellow, 3-7 mm. long; capsule ovoid to oblong-cylindric, brown, often appearing varnished; peristome teeth papillose, short, consisting of 1-10 sections; spores 15-19μ in diameter, rather coarsely papillose, mature in spring. On bare soil in fields, excavations, along roadsides, etc.; Carroll, Crawford, Floyd, Harrison, Henry, Jasper, Jefferson, Lake, Lawrence, Marion, Martin, Monroe, Noble, Owen, Parke, Perry, Porter, Putnam, Spencer, Warren, and *Wayne Counties.

Chromosome Number in Dracaena fragrans

A. T. GUARD and C. H. HOBBS, Purdue University

A specimen of *Dracaena fragrans*, Ker. which had attained some eight feet in height, was growing in the biology greenhouse of Purdue University. This plant had been grown as a house plant prior to being taken to the greenhouse and was estimated to be 12-15 years of age.

During the month of February, 1940, this plant produced a terminal inflorescence. It had been in the greenhouse about two years at that time. Flowering of this species in our latitude is rare, chiefly because it is grown for foliage purposes and the plants are not ordinarily permitted to attain this age. In all its 12-15 years of existence this plant had been repotted but once if at all, and the nitrogen content of the soil was doubtless at a low ebb. It is probable that this plant had a very high carbon-nitrogen ratio, which condition favors flowering. This assumption is further borne out by the fact that large drops of concentrated sugar solution were exuded in various parts of the inflorescence.

Anthesis of the flowers occurred only at night. Blooming was accompanied by a strong but pleasing fragrance. The flowers were ephemeral, lasting but a single night. Each evening about sundown, during the blooming period, the flowers began to unfold and the concomitant fragrance filled the greenhouse. Each morning, likewise, the flowers produced the night before had completely withered, and no trace of the pleasant odor remained. This nocturnal, diurnal production of flowers continued for approximately three weeks. No fruits were set although some flowers were hand-pollinated.

During the early stages of flowering smear mounts of pollen mother cells were made to determine the chromosome number. The haploid number was found to be 21. These chromosomes are small and of uniform size. This is different from many species of Liliaceae which have very large chromosomes. Of the species determined in the Liliaceae the more common numbers are six and eight or multiples thereof. Several species of the genus Aloe have a haploid number of 7. So far as we have been able to ascertain there is no report in the literature of any other species in this family which has 21 as the haploid number of chromosomes.

Kava, Its Preparation and Use

T. G. YUNCKER, DePauw University

Kava, also known as *'ava* and *awa*, is a non-alcoholic beverage of ancient origin, which is still used to a considerable extent in many of the islands of Polynesia. It is a simple and easily prepared watery infusion of parts of *Piper methysticum*. This plant, which is also known by the native names for the drink made from it, is an attractive, slow-growing shrub which eventually may reach a height of ten or more feet. It is to be found on most of the islands in the south Pacific and probably owes its wide distribution to the fact that the aborigines carried it with them in their early migrations.

The part of the plant which is used in preparing the drink is the enlarged basal root-like structure. The beverage is claimed to have a strong narcotic effect followed by drowsiness and sleep, and when it is drunk to excess it produces results which are harmful. Moderately used, however, it is believed to have stimulating or tonic properties and small quantities of the dried root have been marketed for medicinal purposes. It is said that when the effects of the drink wear off that they may be reproduced by merely bathing or lying in water.

The preparation and use of the beverage varies somewhat in different parts of Polynesia. Ordinarily there is considerable ritualistic ceremony associated with its preparation and use, and there is usually no debauchery resulting. On certain islands, Niue, for example, the drinking of kava is frowned upon. A few plants grow there but it is probable that very little, if any, of the drink is prepared nowadays. In Samoa, on the contrary, it is served at nearly every *fono* or village gathering and it is also common for a visitor to be invited to enter a *fale* (house) and have it served as a part of the native hospitality much as Europeans might serve tea. The natives appear to enjoy it, as do some Europeans and Americans also. For the most part, however, the *papalagi* (whites) do not care for it.

As anciently prepared, pieces of the root were chewed, usually by those chiefs' daughters who possessed strong teeth. When reduced to a pulp and sufficiently mixed with saliva it was ejected into a bowl known as the *tanoa*. The bowls used for this purpose have four or more legs and are carved from a single piece of wood, commonly *ifilele (Afzelia bijuga)* a hard-wood species. After a sufficient amount of the juicy matter had been thus prepared, water was added to dilute the mixture which was then cleared with a strainer. Those whites who have witnessed this original, somewhat disgusting method of preparation admit that it required considerable will power to drink the concoction after seeing it prepared.

Very definite regulations dictated the procedure of preparation. The girls who chewed the material must have reached the age of puberty, but be unmarried; children were never allowed to touch the kava root

or the utensils employed in its preparation and serving; untatooed boys could not assist; nor could the person who made the kava talk or laugh during the ceremony.

The modern method of preparing the drink is much as it has always been except that the root is now macerated with a stone pestle instead of being chewed. One old samoan chief complained, however, that the modern drink was not nearly as good as that prepared in the older manner. It has been suggested that some enzymatic action, which would be lacking in the modern process, probably occurs when it is chewed.

A kava ceremony, which includes both the preparation and the drinking of the kava, commonly is the first part of any gathering of importance. The type of ceremony used depends upon the significance of the occasion. An uncommon form is known as the "Royal" or "King's"

Making Kava in Samoa

kava which is held for members of the ruling class. The most unusual of all is the "Sacred" kava which is held only on rare occasions of great significance such as the assuming of office by a new high chief, etc.

In the preparation of the kava for ceremonial purposes several persons take part. A large kava bowl is placed on the ground behind which the person who is to make the kava sits. This position is one of honor and is usually taken by the son or daughter of a high chief. On the right sits an assistant who has charge of the water, while on the left is the cup-bearer. The talking chief who presides also generally sits on the left. Behind and outside the circle usually are one or two others who assist with the straining. The pulverized pieces of Piper are placed in the bowl to which the proper amount of water is added. Sometimes, in order to increase its peppery taste, some fruits of *Capsicum frutescens* are ground up and added. The mixture is then kneaded for a few minutes to insure a proper extraction after which it is cleared with a strainer about two feet long, made of the inner fibrous bark of the *fau* tree

(Hibiscus tiliaceus). The mixer, who is called the *taupou*, draws the strainer through the liquid, collecting the coarser particles. He wrings the strainer then hands or throws it over his shoulder to one of the assistants in the rear who shakes out the fragments with a vigorous whipping motion and returns it. This is repeated several times or until the kava is sufficiently cleared. Sometimes two strainers are used in order to speed the process. When finished the kava is a slightly milky substance which somewhat resembles dishwater. It is rather peppery to the taste, and leaves the mouth and throat with a peculiar, slightly puckery sensation. However, no other reaction was experienced by the writer from the drinking of comparatively small amounts.

When the preparation of the kava is completed the officiating talking chief proclaims the fact in a loud voice, whereupon all present slowly clap their hands in unison several times, announcing to the village that the kava is made.

The beverage is served in a coconut shell cup called the *ipu*. The *taupou* fills the cup by squeezing the strainer full of liquid over it. It is then passed to the proper person whose name is announced in a loud voice by the presiding chief. The recipient takes the cup, carefully spills a small amount on the floor as a libation, says "*Manuia*" (your health), to which all respond with "*Manuia*" or "*Soi fua*" (life to you), then drains the contents of the cup. The cup is returned for refilling, and the performance is repeated until all have been served.

All of the movements of serving and receiving the cup of kava are strictly prescribed by ancient ritual which varies according to the rank of the person being served. At the conclusion the bowl and other equipment are removed and the meeting gets under way.

The sacred ceremony differs to a considerable extent from the ordinary type and is exceedingly impressive. It was my privilege, on the occasion of the American governor's visit to the outlying islands of American Samoa, to participate in the first sacred ceremony given in Manua since 1909. An important feature of the ceremony is a period of absolute silence and immobility on the part of those participating. The guests are seated within the *fale* at alternate posts, with the participating chiefs sitting between. At the proper point in the proceedings a signal is given by the presiding chief, whereupon everyone present is expected to "freeze," and to remain absolutely silent and motionless until the releasing signal is given. This may last a few minutes or much longer. It is said that in earlier times anyone who disturbed the ceremony by noise or movement was promptly impaled on a spear and that this "legal" elimination of certain persons was sometimes caused by extending the quiet period until the individual's self-control snapped.

Though excessive indulgence in kava may bring about undesirable physical effects, it is believed to produce less serious results than the drinking of alcoholic beverages which, for the most part, owe their introduction to the white man.

Indiana Plant Distribution Records, 1940

In an attempt to keep the distribution records of Deam's "Flora of Indiana" up to date it is planned to publish each year a list of the species collected in counties not previously shown for the species listed. Records are published only when backed by one or more specimens deposited in an institutional herbarium or in one of the private herbaria listed in the "Flora." Species names are listed in same order as that used by Mr. Deam and symbols following the species are those used by him for the herbaria in which the specimens reported are deposited. Species new for the state are listed in bold face type. The following new institutional herbaria are additions to those listed in the "Flora": E, Earlham College.

Contributors to this report can reduce the work of the committee in compiling this report if they will adhere to the following suggestions.

1. Submit list in "column" form showing the generic number, the name of the plant, the county where collected, and the herbarium where specimen is deposited.
2. List the genera in order according to generic number and the species in alphabetical order under the genera.
3. Species, varieties, or forms new to the state and hence not in the "Flora" should be marked for bold face type.
4. New segregations and nomenclatorial changes should show reference where such have been published.
5. All new records must be backed by a specimen deposited in an institutional herbarium or in one of the private herbaria listed in the "Flora" pp. 11, 12. No new private herbaria will be recognized as depositories. Other institutional herbaria may be recognized and appropriate symbols assigned. All collectors are urged to send duplicates of their specimens to the Deam Herbarium at Indiana University.

The specimens here listed have been collected as follows:—Butler University: Charles M. Ek, Ray C. Friesner, Scott McCoy, and John E. Potzger. Deam Herbarium: Charles C. Deam. Earlham College: Lawrence J. King. DePauw University: Winona Welch. Indiana Unisersity; E. D. Hull and Virginia Michaud.

SPECIES

Ophioglossum engelmanni, Harrison (B). *Onoclea sensibilis*, LaPorte (B). *Dryopteris spinulosa intermedia*, Steuben (D). *Athyrium thelypteroides*, Lagrange (D). *Asplenium platyneuron*, Tippecanoe (B). *A. pinnatifidum*, Putnam (DP). *Pteridium latiusculum*, Kosciusko (B). *Equisetum fluviatile*, Kosciusko (B). *E. laevigatum*, White (B), Pulaski (B). *Lyopodium lucidulum*, Crawford (B). *Selaginella apoda*, LaPorte (B). *Larix laricina*, Kosciusko (B). *Typha angustifolia*, White (B). *Potamogeton americanus*, Howard (B). *Triglochin maritima*, LaPorte (B). *Sagittaria brevirostra*, Knox (D). *S. latifolia*, Rush (D). *S. rigida*,

Marshall (B). *Anacharis canadensis,* White (B). *Arundinaria gigantea,* Martin (B). *Bromus latiglumis,* LaPorte (B). *Festuca paradoxa,* Greene (IU). *Poa wolfii,* Owen (B). *Eragrostis frankii,* Perry (D). *E. hypnoides,* Knox (D), Perry (D). *Uniola latifolia,* Montgomery (B). *Phragmites communis,* Starke (B), Kosciusko (B). *Elymus riparius,* Kosciusko (B), Cass (B), White (B), Knox (D). *E. villosus,* Lagrange (D). *Koeleria cristata,* Tippecanoe (B). *Arrhenatherum elatius,* Howard (B). *Alopecurus pratensis,* Marion (B). *Aristida longispica,* Perry (D). *A. oligantha,* Marshall (B), Starke (B). *A. purpurascens,* Marshall (D), Perry (D). *Digitaria ischaemum,* Elkhart (D). *Sphenopholis obtusata,* Kosciusko (D). *Muhlenbergia mexicana,* Rush (D). *M. schreberi,* Kosciusko (D). *Sporobolus asper,* Elkhart (D). *Panicum anceps,* Harrison (B). *P. capillare,* Rush (D). *P. meridionale,* Elkhart (D). *P. microcarpon,* Elkhart (D), Lagrange (D). *P. perlongum,* Pulaski (D). *P. praecocius,* Jasper (B). *P. pseudopubescens,* Fulton (D). *Setaria italica,* Knox (D). *S. lutescens,* Crawford (D). *Leersia oryzoides,* Rush (D). *Sorghastrum nutans,* Pulaski (B), White (B). *Cyperus esculentus,* Rush (D). *C. pseudovegetus,* Gibson (D). *Scirpus atrovirens georgianus,* Posey (D). *S. cyperinus,* Kosciusko (B). *S. polyphyllus,* Harrison (D). *S. smithii setosus,* Cass (B). *S. validus,* Howard (B), Rush (D). *Eleocharis tenuis verrucosa,* Newton (B). *E. olivacea,* Cass (B). *Cladium mariscoides,* Newton (B). *Rhyncospora macrostachya,* St. Joseph (B). *Scleria triglomerata,* Starke (B). *S. verticillata,* LaPorte (B), St. Joseph (B). *Carex aggregata,* St. Joseph (B). *C. albolutescens,* Jackson (D). *C. albursina,* Kosciusko (B). *C. annectens,* Jackson (D). *C. artitecta,* Martin (D). *C. aurea,* Kosciusko (B). *C. bebbii,* Kosciusko (B). *C. brevior,* White (B), Kosciusko (B). *C. buxbaumii,* Miami (B). *C. cephalophora,* Cass (B). *C. communis,* Fulton (B). *C. cristatella,* Pulaski (B). *C. cryptolepis,* Kosciusko (B). *C. granularis,* Kosciusko (B), Crawford (B). *C. hitchcockiana,* Kosciusko (B). *C. laxiflora serrulata,* Miami (B). *C. leavenworthii,* Howard (B). *C. lupulina,* Cass (B). *C. lurida,* Kosciusko (B). *C. molesta,* Harrison (D). *C. riparia lacustris,* Kosciusko (B). *C. squarrosa,* Tipton (B). *C. stipata,* Miami (B). *C. stricta,* Kosciusko (B). *C. swanii,* Kosciusko (B), Crawford (B). *C. tenera,* Kosciusko (B). *C. tribuloides,* Marshall (B). *C. umbellata,* Martin (B), (D), Perry (D). *C. virescens,* Clark (D). *C. vulpinoidea,* Fulton (B). *C. vulpinoidea* **pycnocephala,** Elkhart (D), See Flora p. 272. *Symplocarpus foetidus,* LaPorte (B). *Spirodela polyrhiza,* Howard (B). *Commelina virginica,* Harrison (B), (D). *Juncus acuminatus,* Cass (D), White (B). *J. balticus littoralis dissitiflorus,* Newton (B). *J. brachycephalus,* Pulaski (B). *J. effusus solutus,* Bartholomew (B). *Luzula echinata,* Martin (B), (D), Perry (D). *L. echinata mesochorea,* Harrison (D). *Chamaelirium luteum,* Harrison (B). *Uvularia grandiflora,* Cass (B). *Allium sativum,* Cass (B), Tippecanoe (B). *Lilium philadelphicum andinum,* White (B). *Erythronium albidum* **mesochoreum,** Crawford (D). *E. americanum,* Owen (B). *Asparagus officinalis,* Tipton (B). *Smilacina stellata,* Miami (B). *Maianthemum canadense interius,* Kosciusko (B).

Polygonatum canaliculatum, Kosciusko (B), Newton (B). *P. pubescens*, Harrison (B). *Medeola virginiana*, Crawford (B). *Trillium sessile*, Crawford (B), (D). *T. nivale*, Crawford (B). *Aletris farinosa*, Fulton (B). *Smilax herbacea lasioneuron*, White (B). *Dioscorea villosa*, Fulton (B). *Iris cristata*, Orange (B), (D). *Sisyrinchium albidum*, Daviess (B). *S. graminoides*, Bartholomew (B). *Cypripedium reginae*, Kosciusko (B). *C. calceolus pubescens*, Starke (B). *Habenaria flava*, Marshall (B). *H. lacera*, Starke (B). *H. leucophaea*, Starke (B). *Spiranthes lucida*, Kosciusko (B). *Corallorrhiza odontorhiza*, Putnam (DP). *Populus tremuloides*, Fulton (B). *Salix amygdaloides*, Cass (B). *S. discolor latifolia*, Kosciusko (B). *S. glaucophylla*, Starke (B). *S. humilis*, Pulaski (B), Fulton (B), Jasper (B). *S. nigra*, Cass (B). *S. sericea*, Starke (B). *Juglans cinerea*, Martin (B). *J. nigra*, Martin (B). *Carya laciniosa*, Tippecanoe (B). *C. ovalis*, Pulaski (B), Martin (B). *C. ovata*, Martin (B), Bartholomew (B). *C. tomentosa*, Fulton (B). *Fagus grandifolia*, Pike (D). *Quercus alba*, Starke (B), Martin (B). *Q. borealis maxima*, Martin (B), Spencer (D). *Q. coccinea*, Crawford (D). *Q. imbricaria*, Martin (B). *Q. muhlenbergii*, Martin (B). *Q. palustris*, Harrison (D), Martin (B). *Q. shumardii schneckii*, Howard (B). *Q. velutina*, St. Joseph (B), Martin (B). *Ulmus americana*, Starke (B), Martin (B). *U. fulva*, Martin (B). *Celtis occidentalis crassifolia*, Posey (B), Martin (B). *Morus rubra*, Martin (B), Starke (B). *Cannabis sativa*, Howard (B). *Rumex acetosella*, Starke (B), Pulaski (B). *R. crispus*, Steuben (D). *R. triangularivalvis*, Harrison (D). *Polygonum buxiforme*, Howard (B), Marshall (B). *P. coccineum*, Marshall (B). *P. erectum*, Howard (B). *P. hydropiperoides*, Greene (D), Cass (B), Kosciusko (B), Pulaski (B). *P. neglectum*, Howard (B). *P. pennsylvanicum laevigatum*, White (B). *P. p. laevigatum pallescens*, Kosciusko (B), Rush (D), Spencer (D). *P. punctatum*, Marion (B), Rush (D). *P. scandens*, Marshall (B). *Chenopodium album*, Posey (D). *C. Berlandieri*, Cass (B). *Cycloloma atriplicifolium*, Howard (B). *Corispermum hyssopifolium*, Howard (B). *Atriplex patula hastata*, Howard (B). *A. p. littoralis*, Tipton (B), Howard (B). *Amaranthus hybridus*, Kosciusko (B), Rush (D). *A. blitoides*, White (B). *A. graecizans*, Howard (B), Rush (D). *Oxybaphus nyctagineus*, White (B). *Claytonia virginica*, Orange (B). *Portulaca oleracea*, White (B), Howard (B). *Stellaria graminea*, Howard (B). *S. longifolia*, Miami (B). *S. media*, Tippecanoe (B). *S. pubera*, Martin (B), (D). *Cerastium viscosum*, Martin (D). *C. vulgatum hirsutum*, Starke (B). *Silene stellata scabrella*, Harrison (D). *S. virginica*, Kosciusko (B). *Nuphar advenum*, Howard (B), Starke (B). *Hydrastis canadensis*, Crawford (B), (D). *Anemone quinquefolia interior*, Crawford (B), (D). *Clematis virginiana*, Cass (B). *Ranunculus flabellaris*, Cass (B). *R. longirostris*, Jasper (B). *R. abortivus*, Crawford (D), Martin (B), (D). *Thalictrum perelegans*, Harrison (D). *T. revolutum*, Pulaski (B), Fulton (B). *Jeffersonia diphylla*, Tippecanoe (B). *Menispermum canadense*, LaPorte (B). *Magnolia acuminata*, Harrison (B), (D). *Liriodendron tulipifera*, Martin (B). *Sassafras albidum*, Lagrange (B), Fulton (B), Vigo (B), Johnson (B), Morgan (B), Sullivan (B), Greene (B), Monroe (B),

Bartholomew (B), Ripley (B), Dearborn (B), Knox (B), Martin (B), Lawrence (B), Washington (B), Jefferson (B), Switzerland (B), Crawford (B). *S. albidum molle*, Howard (B). *Dicentra cucullaria*, Owen (B). *Lepidium virginicum*, Posey (B). *Sisymbrium altissimum*, Tippecanoe (B). *S. officinale leiocarpum*, Starke (B). *S. thalianum*, Crawford (B), (D), Martin (D), Perry (D). *Rorippa sylvestris*, Cass (D). *Cardamine bulbosa*, Martin (B). *C. douglassii*, Owen (B). *C. pariflora arenicola*, Crawford (B), Martin (B). *C. pennsylvanica*, Fulton (B). *Dentaria laciniata*, Martin (D), Orange (B). *Camelina microcarpa*, Tippecanoe (B). *Draba brachycarpa*, Crawford (B), (D), Martin (D), Orange (B), (D). *D. verna*, Harrison (B), Crawford (B), (D). *Arabis canadensis*, Tippecanoe (B). *A. glabra*, Tippecanoe (B), Howard (B). *A. pycnocarpa*, Kosciusko (B). *A. virginica*, Crawford (B), (D), Orange (B), (D). *Descurainia pinnata brachycarpa*, Harrison (D). *Erysimum cheiranthoides*, Miami (B). *Drosera rotundifolia*, Kosciusko (B). *Penthorum sedioides*, Elkhart (D), LaPorte (B). *Heuchera americana interior*, White (B). *H. parviflora rugelii*, Crawford (D). *Liquidambar styraciflua*, Harrison (B). *Hamamelis virginiana*, Martin (B). *Malus coronaria*, Tippecanoe (B). *Aronia prunifolia*, Kosciusko (B). *Crataegus mollis*, Tippecanoe (B). *C. rugosa*, Howard (B). *Rubus flagellaris*, Martin (B), Harrison (B). *R. idaeus strigosus*, Kosciusko (B). *R. occidentalis*, Starke (B). *Potentilla simplex typica*, Franklin (B), Fulton (B). *Geum laciniatum*, St. Joseph (B). *G. laciniatum trichocarpum*, Marshall (B), Starke (B). *Agrimonia parviflora*, Marshall (B). *Rosa carolina*, Howard (B). *R. setigera tomentosa*, Ohio (B). *Prunus serotina*, Starke (B), Martin (B). *Cassia hebecarpa*, Jay (D). *C. marilandica*, Harrison (D). *Gleditsia triacanthos*, Harrison (D), Kosciusko (D). X **Baptisia deamii** Larisey (*B. leucantha* x *tinctoria*), Starke (D). *Trifolium agrarium*, Starke (B). *Petalostemum candidum*, Pulaski (B). *Tephrosia virginiana*, White (B). *Robinia pseudo-acacia*, Cass (B). *Desmodium canadense*, Howard (B). *D. rigidum*, Marshall (B). *D. sessilifolium*, Pulaski (B). *Lespedeza intermedia*, Marshall (B). *L. intermedia hahnii*, Perry (D). *L. nuttallii*, Crawford (B). *L. procumbens*, Clark (D). *L. violacea*, Harrison (B). *L. virginica*, Kosciusko (B). *Lathyrus palustris myrtifolius*, Pulaski (B), Fulton (B), Marion (B). *L. p. linearifolius*, Miami (B). *Oxalis europaea bushii subglabrata*, Fulton (B). *O. europaea cymosa*, Starke (B), LaPorte (B). *O. europaea villicaulis*, Martin (B). *O. violacea trichophora*, Crawford (B). *Polygala cruciata*, Pulaski (B). *P. verticillata sphenostachya*, White (B). *Croton capitatus*, Harrison (B), (D). *Acalypha gracilens*, Daviess (D). *A. rhomboidea*, Rush (D), Starke (B). *Tragia cordata*, Perry (D). *Euphorbia commutata*, Martin (D). *E. corollata*, Elkhart (D), Harrison (D). *E. maculata*, Marshall (B). *Rhus aromatica*, Kosciusko (B). *R. vernix*, St. Joseph (B). *Acer nigrum*, Harrison (D). *A. rubrum drummondii*, Gibson (D). *Aesculus octandra*, Washington (D). *Tilia americana*, Howard (B). *Abutilon theophrasti*, Rush (D). *Malva neglecta*, Rush (D). *Sida spinosa*, Rush (D). *Hypericum boreale*, Starke (B). *H. cistifolium*, Pulaski (B). *H. gentianoides*, Crawford (B). *H. perforatum*, Martin (B). *H. sphaerocarpum*, Pulaski (B). *H.*

virginicum fraseri, Howard (B). *Helianthemum bicknellii*, Pulaski (B), Tippecanoe (B). *Lechea tenuifolia*, Daviess (D), Newton (B). *L. villosa*, Elkhart (D). *Viola eriocarpa leiocarpa*, Crawford (B). *V. kitaibeliana rafinesquii*, Harrison (D), Orange (B). *V. pedata*, Fulton (B). *V. sagittata*, Pulaski (B). *Decodon verticillatus*, Dubois (D). *Spermolepis patens*, Cass (B). *Ludvigia alternifolia*, LaPorte (B). *L. palustris americana*, St. Joseph (B). *Epilobium coloratum*, Pulaski (B), Ohio (B). *Oenothera laciniata*, Johnson (B), Marion (B), Tippecanoe (B), Steuben (D). *Oe. perennis*, Bartholomew (B). *Oe. pycnocarpa*, Fulton (B). *Oe. speciosa*, Howard (B). *Oe. tetragona longistipata*, Fulton (B). *Proserpinaca palustris crebra*, St. Joseph (B). *Aralia nudicaulis*, Newton (B). *Sanicula canadensis*, Fulton (B), Tipton (B). *Erigenia bulbosa*, Orange (D). *Thaspium barbinode*, Kosciusko (D). *Daucus carota*, Cass (B). *Nyssa sylvatica*, Dearborn (B), Ohio (B). *Cornus florida*, Martin (B). *C. racemosa*, Kosciusko (B). *Vaccinium vacillans crinitum*, Crawford (B). *Lysimachia lanceolata*, Jasper (B), White (B), Martin (B). *L. longifolia*, LaPorte (B). *Anagallis arvensis*, Bartholomew (B), Harrison (B). *Diospyros virginiana*, Martin (B). *Fraxinus americana*, Howard (B). *F. pennsylvanica*, Martin (B). *Gentiana andrewsii*, Pulaski (B), Howard (B). *G. procera*, Starke (B). *Frasera caroliniensis*, Harrison (B), (D). *Apocynum androsaemifolium*, Tipton (B). *A. cannabinum*, Bartholomew (B), White (B). *A. c. glaberrimum*, Pulaski (B), White (B), Howard (B). *A. c. pubescens*, Crawford (D), Tipton (B). *A. medium leuconeuron*, Marshall (B). *A. sibiricum farwellii*, White (B). *Asclepias incarnata*, Harrison (D). *A. purpurascens*, Marshall (B), Fulton (B), Pulaski (B). *A. sullivantii*, Pulaski (B). *A. syriaca*, Cass (B), Pulaski (B), Fulton (B). *A. variegata*, Harrison (B). *A. verticillata*, Kosciusko (D). *Cuscuta pentagona*, Cass (D). *Convolvulus repens*, Martin (B). *C. sepium*, Fulton (B). *S. tenuifolia*, Harrison (B). *Monarda fistulosa*, Cass (B), *Lithospermum croceum*, Tippecanoe (B). *Teucrium occidentale*, Jasper (B). *Scutellaria lateriflora*, Crawford (B). *Prunella vulgaris lanceolata*, Starke (B). *Physostegia speciosa*, Rush (D). *P. virginiana*, Harrison (D). *Lamium amplexicaule*, Perry (D), Tipton (B). *Stachys hispida*, Tipton (B). *S. hyssopifolia*, Kosciusko (D). *S. palustris homotrichia*, Fulton (B). *S. tenuifolia*, Harrison (B). *Monarda fistulosa* ,Cass (B), Newton (B). *M. punctata villicaulis*, Elkhart (D). *Hedeoma hispida*, White (B). *H. pulegioides*, Martin (B). *Pycnanthemum flexuosum*, Fulton (B). *P. virginianum*, LaPorte (B). *Lycopus americanus*, Rush (D), LaPorte (B). *L. a. longii*, Cass (B). *L. uniflorus*, Pike (D). *L. virginicus*, Knox (D). *Mentha longifolia mollissima*, Howard (B), (D). *M. piperita*, Tippecanoe, (B). *M. spicata*, Cass (B). *Nicandra physalodes*, Howard (B). *Lycium halimifolium*, Howard (B). *Physalis heterophylla*, Starke (B). *P. pruinosa*, Crawford (D). *P. virginiana*, Starke (D). *Verbascum thapsus*, Martin (B), Fulton (B). *Linaria vulgaris*, Marshall (B). *Scrophularia marilandica*, Brown (B). *Pentstemon pallidus*, Clark (D). *Leucospora multifida*, Rush (D). *Lindernia dubia typica*, Greene (D). *Veronica officinalis*, Brown (B). *Gerardia*

paupercula borealis, Kosciusko (D). *G. tenuifolia parviflora*, LaPorte (B). *Pedicularis lanceolata*, Howard (B). *Orobanche ludoviciana*, Knox (D). *Ruellia strepens*, Harrison (B). *Dicliptera brachiata*, Harrison (B), (D), (E). *Plantago indica*, Tipton (B). *P. rugelli*, Rush (D). *P. r. asperula*, Steuben (D). *Cephalanthus occidentalis*, Harrison (D). *Galium boreale*, Pulaski (B). *G. b. intermedium*, Kosciusko (B). *G. circaezans hypomalacum*, Fulton (B), Martin (B). *G. concinnum*, Starke (B), Fulton (B), Howard (B), Martin (B). *G. obtusum*, Starke (B). *G. pilosum*, Kosciusko (D). *G. trifidum*, Steuben (B). *G. triflorum*, Starke (B). *Sambucus canadensis*, Martin (B). *Triosteum aurantiacum*, Madison (B). *Symphoricarpos orbiculatus*, Johnson (B). *Lonicera dioica*, Starke (B). *Diervilla lonicera*, St. Joseph (B). *Sicyos angulatus*, Harrison (B), (D). *Lobelia siphilitica albiflora*, Elkhart (D). *L. spicata originalis*, Cass (D), Jasper (B), Steuben (B). *L. s. hirtella*, White (B). *Eupatorium altissimum*, Tipton (B), Jay (D). *E. fistulosum*, Cass (B). *E. perfoliatum*, Harrison (D). *Solidago altissima*, Marshall (B). *S. gigantea leiophylla*, Marshall (B). *S. media*, Marshall (B). *S. nemoralis decemflora*, Starke (B). *S. ohioensis*, Starke (B). *S. speciosa*, Knox (D). *S. uniligulata*, LaPorte (B). **Aster amethystinus**, Tipton (B), (D). *A. cordifolius*, Starke (B). *A. drummondii*, Spencer (D). *A. exiguus*, Starke (B). *A. ericoides*, Starke (B). *A. junceus*, Kosciusko (B). *A. lateriflorus*, LaPorte (B). *A. missouriensis*, Posey (D). *A. missouriensis thyrsoides*, Tipton (B). *A. novae-angliae*, LaPorte (B). *A. paniculatus*, Starke (B), White (B). *A. p. simplex*, Howard (B), Brown (B). *A. praealtus*, Starke (B). *A. p. angustior, Starke* (B), White (B), Tipton (B). *A. puniceus*, Starke (B). *A. sagittifolius purpureum*, Starke (B). *Silphium laciniatum*, Newton (B), Pulaski (B). *E. pulchellus*, Posey (B). *E. pusillus*, Crawford (B). *Antennaria neodioica*, Harrison (D). *A. parlinii*, Martin (D). *Gnaphalium purpurem*, Starke (B). *Silphium laciniatum*, Newton (B), Pulaski (B). *Iva ciliata*, Gibson (D). *Ambrosia coronopifolia*, White (B). *A. elatior*, White (B), Tipton (B). *A. trifida*, Harrison (D). *Rudbeckia subtomentosa*, Cass (B). *R. triloba*, Crawford (D). *Helianthus decapetalus*, Tippecanoe (B). *H. divaricatus*, Harrison (D). *H. giganteus*, White (B). *H. microcephalis*, Knox (D). *H. occidentalis*, Tippecanoe (B). *H. rigidus*, Marion (B). *Bidens bipinnata*, Crawford (D). *B. comosa*, Kosciusko (B), White (B), Starke (B), Rush (D). *B. coronata tenuiloba*, LaPorte (B), Starke (B). *B. vulgata*, Kosciusko (B), LaPorte (B). *Helenium autumnale*, Rush (D). *Chrysanthemum leucanthemum pinnatifidum*, St. Joseph (B). *Artemisia gnaphalodes*, Starke (B). *Erechtites hieracifolia*, Marshall (B). *Cacalia muhlenbergia*, Harrison (D). *Senecio aureus*, Starke (B), Martin (B), Harrison (D). *Krigia virginica*, White (B). *Tragopogon pratensis*, Tippecanoe (B). *Sonchus arvensis glabrescens*, Whitley (D). *Lactuca canadensis obovata*, Harrison (D). *L. saligna*, Harrison (D). *L. scariola integrata*, Howard (B). *L. villosa*, Howard (B). *Pyrrhopappus carolinianus*, Gibson (D). *Prenanthes aspera*, Spencer (D). *Hieracium gronovii*, Elkhart (D).

ADDITIONAL SPECIES ADDED TO THE DEAM HERBARIUM

The following species previously reported in other herbaria for certain counties have been added to the Deam Herbarium.

Alopecurus carolinianus, Jefferson. *Agrostis hyemalis,* Jefferson. *Poa sylvestris,* Clark. *Arundinaria gigantea,* Lawrence. *Corylus americana,* Harrison. *Quercus marilandica,* Clark. *Q. shumardii,* Perry. *Cannabis sativa,* Kosciusko. *Rumex acetosella,* Jefferson. *Polygonum virginianum,* Kosciusko. *Dentaria heterophylla,* Orange. *Arabis laevigata,* Martin. *Desmodium rotundifolium,* Crawford. *Geranium maculatum,* Crawford. *Oxalis violacea trichophora,* Harrison, Martin. *Veronica officinalis,* Jefferson. *Elephantopus carolinianus,* Crawford. *Helianthus mollis,* Harrison.

State Flora Committee: Charles C. Deam
Ray C. Friesner
Ralph Kriebel
Truman G. Yuncker

CHEMISTRY

Chairman: KARL S. MEANS, Butler University

J. L. Riebsomer, DePauw University, was elected chairman of the section for 1941.

ABSTRACTS

Permeability of human red cells to sodium and potassium ions. DR. K. LARK-HOROVITZ and H. LENG, Purdue University.—Radioactive NaCl and KCl have been administered orally in aqueous solution and in ordinary capsules for absorption from the stomach and by capsules in enteric coatings for absorption from the small intestine. The time rate of intake in the blood has been studied by measuring the activity of blood samples taken from the fingertips or from the vein in intervals up to 40 hours. By centrifuging, the cells have been separated from the plasma. It has been found that the amount absorbed is proportional to the intake and by measuring the distribution of the ions between plasma and cells the exchange ratio has been determined. Whereas 80 to 100% of the sodium ions in the cells are exchanged only 10 to 20% of the potassium ions are able to penetrate.

Testing of enteric coatings with radioactive indicators. DR. K. LARK-HOROVITZ and H. LENG, Purdue University.—Capsules filled with radioactive sodium chloride have been covered with enteric coatings of different makes and the efficacy of the coatings has been studied in the following way. The capsule is followed on its way through the digestive tract by means of a thin wall counter. It can be located quite accurately, and by taking the number of counts, it can be definitely established whether the capsule holds together, leaks or breaks. Using a second counter to observe the activity in the hand, the time when the radioactive material appears in the blood stream is determined. A commercial coating following a prescription of Professor C. O. Lee of the Purdue School of Pharmacy has been used and it has been found that the latter coating is far more reliable than the commercial one.

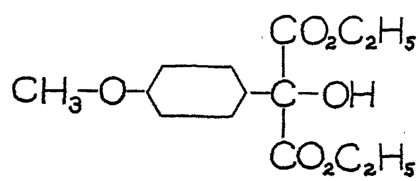
Relation of valence and nomenclature to formulas for the negative ions of ternary inorganic compounds. K. S. MEANS, Butler University.—Group numbers for the different elements can be used in determining their valences. For this purpose the Periodic Table is divided into three parts. Nomenclature is used to determine the valence of the element in a given ion as well as the elements present. Also the name in some instances designates the number of atoms of a given element in the ion, such as dichromate, where there are two atoms of chromium. In ternary compounds the negative ion consists of two elements one of which is usually oxygen. From the negative charge of the oxygen, and the positive charge of the other element, the amount of oxygen in the ion of the meta compound can be determined since the ion must be negative.

Further Observations on the Synthesis of Mandelic Acid Derivatives

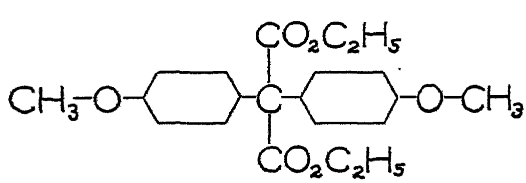
J. L. RIEBSOMER, PARK WISEMAN and GEORGE CONDIKE,
DePauw University

During the past four years we have synthesized more than thirty substituted mandelic acids. The method used for the most of these syntheses has been described previously in this journal and elsewhere,[1, 2] and consists essentially of reacting benzene or a substituted benzene with ethyl oxomalonate in the presence of anhydrous stannic chloride. The aryl hydroxy substituted malonic esters thus produced are saponified with potassium hydroxide acidified with hydrochloric acid and decarboxylated, producing the corresponding mandelic acids.

Early in the course of these syntheses, the senior author attempted to prepare p-methoxy mandelic acid by reacting anisole with ethyl oxomalonate and stannic chloride. The intermediate expected following the usual reaction scheme was:



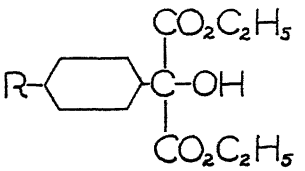
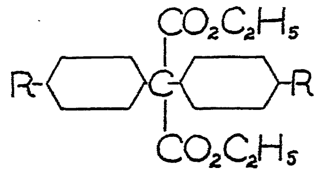
But the compound formed boiled much higher than predicted and was practically unaffected when saponification was attempted in twenty per cent aqueous potassium hydroxide. The aqueous alkali was extracted with ether and the unsaponifiable material purified. Analysis and the melting point indicated this compound to be (I).

(I) 

This reaction is what one might expect inasmuch as the para hydrogen of phenolic compounds is more reactive than in alkyl substituted benzenes.

[1] Riebsomer, Irvine and Andrews, 1938. Proc. Indiana Acad. Sci. 47:139.
[2] Riebsomer, Irvine and Andrews, 1938. J. Amer. Chem. Soc. 60:1015.

This same compound had been prepared previously[4] by treating an anisole-ethyl oxomalonate mixture with concentrated sulphuric acid instead of anhydrous stannic chloride. These same authors had also demonstrated that concentrated sulphuric acid would induce a reaction between alkyl benzenes and ethyl oxomalonate to produce a mixture of (II) and (III)

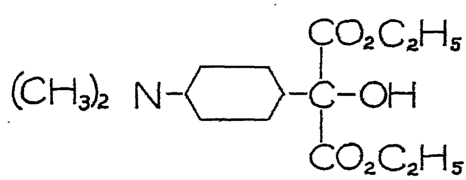
(II)  (III) 

but failed to state any details about yields and experimental conditions.

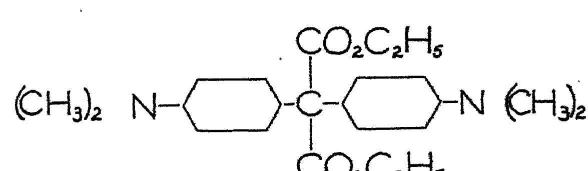
Since certain of the substituted mandelic acids prepared previously had shown marked bactericidal properties in vitro and had some commercial promise, and since concentrated sulphuric acid was less expensive and more convenient to handle than anhydrous stannic chloride, a study was made using a variety of concentrations of sulphuric acid in a typical synthesis to determine its efficacy as the condensing agent.

In nearly all cases when concentrated sulphuric acid was used as the condensing agent, both compounds (I) and (II) were produced but always in a relatively poor yields. Table I in the experimental part summarizes the results.

These results with concentrated sulphuric acid stimulated interest in the use of certain other condensing agents. As early as 1909, Guyot and Michel[5] showed that dimethyl aniline and other comparable compounds and ethyl oxomalonate in the presence of glacial acetic acid reacted readily to form compounds such as (IV)

(IV) 

and that by treating (IV) with excess dimethyl aniline in the presence of phosphorous oxychloride that compound (V) was produced.

(V) 

[4] Guyot and Esteva, 1909. Comp. Rend. 148:719.
[5] Guyot and Michel, 1909. Comp. Rend., 148:229.

Accordingly acetic anhydride was substituted for anhydrous stannic chloride in the general synthesis using toluene as the hydrocarbon, also with anisole and with phenol. None of the expected product was formed in any of these cases.

Similar experiments were tried using individually dry hydrogen chloride, phosphorous oxychloride and phosphorous pentachloride as the condensing agent, but none of these reagents were capable of bringing about the desired reaction.

Experimental

Di-p-Methoxy Malonic ester. Seventeen grams of ethyl oxomalonate and 43.2 grams of anisole were mixed in a three-necked flask equipped with a stirrer, condenser and dropping funnel. Anhydrous stannic chloride (50 g.) was added slowly with stirring keeping the temperature at 0°, and the stirring continued for 5 hours. The reaction product was added to ice and hydrochloric acid, extracted with ether, dried and distilled. The main product distilled at 225° to 230° at a pressure of 2 mm. Yield 22 g. This product was heated on a steam bath with 20% aqueous potassium hydroxide for 6 hours. Most of the product failed to go into solution. It was extracted with ether, washed, dried and recrystallized from ethyl alcohol. M.p. 74-75°. Combustion analysis: calcd. for

$$(CH_3OC_6H_4)_2{=}C{=}(CO_2C_2H_5)_2$$

C, 67.4; H, 6.4: found, C, 67.1, H, 6.4.

Series of reactions using concentrated sulphuric acid in place of anhydrous stannic chloride. The procedure was the same in each case except the quantities of sulphuric acid were varied. In each case 0.1 mole of ethyl oxomalonate, 0.24 moles of toluene were mixed with a three-necked flask, and the sulphuric acid added with stirring at 0° and the stirring continued for three hours. The product was poured into ice-water and worked up in the usual manner. The intermediate was saponified with 20% potassium hydroxide for 4 to 5 hours and the unsaponifiable portion extracted with ether, dried and weighed. The saponified portion was acidified with hydrochloric acid, decarboxylated, extracted with ether, crystallized from benzene and weighed. This portion was p-methyl mandelic acid, m.p. 143°. The unsaponifibale portion was diethyl di-p-tolyl malonate which after one crystallization from ethyl alcohol melted at 92-93°. The data are summarized in table I.

TABLE I

Moles of Sulphuric Acid	Percentage Yield of p-Methyl Mandelic Acid	Percentage Yield of Diethyl di-p-Tolyl Malonate
.01	3.3	negligible
.05	3.5	less than 1
0.1	16.7	2.3
0.15	14.7	13.0
0.22	12.0	16.0

Acetic anhydride as condensing agent. Twenty-eight grams of anisole, 8.7 grams of ethyl oxomalonate and 15.3 grams of acetic anhydride were stirred together at 25° for two hours. The mixture was subjected to distillation. All the material distilled up to 90° at 25 mm. which meant no reaction had taken place. This same reaction at the temperature of a steam bath also failed.

A similar reaction was tried using 23 grams of toluene, 8.7 grams of ethyl oxomalonate and 10.2 grams of acetic anhydride and heating on a steam bath for four hours. Upon distillation only the starting materials were recovered.

When 23 grams phenol, 8.7 grams of ethyl oxomalonate and 10.2 grams of acetic anhydride were stirred four hours at 100° about 1.5 grams of a liquid, b.p. 130-140° at 3 mm. was isolated. This product was saponified in the usual manner and acidified after saponification with hydrochloric acid. The product was black and nothing could be crystallized from it.

Hydrogen Chloride as the condensing agent. Fifty-two grams of ethyl oxomalonate and 5.5 grams of toluene were mixed in a flask kept at 0°, and dry hydrogen chloride gas was introduced until it began to pass through. The product was washed with water, and distilled. None of the expected intermediate was formed. A similar experiment using phenol instead of toluene also failed.

Phosphorous pentachloride and phosphorous oxychloride as the condensing agents. Twenty-three grams of toluene, 8.7 grams of ethyl oxomalonate and 15.6 grams of phosphorous pentachloride were mixed in a three-necked flask at 20° and stirred for three hours. The mixture was poured into ice-water, washed and distilled in the usual manner. The entire product distilled before the temperature had reached 115° at 3 mm. Therefore there was none of the desired reaction. An exactly similar experiment with phosphorous oxychloride also failed.

The authors wish to express their gratefulness to Dean William M. Blanchard, who was instrumental in securing a research grant from the Indiana Academy of Science to promote our research program.

Summary

1. When anisole is used in the Ando synthesis instead of benzene hydrocarbons, the reaction takes an unusual course and di-p-methoxyphenyl malonic ester is formed.

2. Concentrated sulphuric acid used instead of anhydrous stannic chloride in this synthesis produces diaryl malonic esters as well as the expected aryl hydroxy malonic esters, but always in relatively poor yields.

3. Acetic anhydride, dry hydrogen chloride gas, phosphorous pentachloride and phosphorous oxychloride when used instead of stannic chloride in the Ando synthesis fail to promote the reactions.

The Lumistat, an Aid in the Study of Chemiluminescence

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In any photographic or photometric work pertaining to chemiluminescence, it is necessary to have some means of maintaining the luminescence over a period of time. Also it is desirable to keep the intensity of the luminescence as nearly constant as possible while it is being studied.

In a recent article[1], the writer described a device which was used in maintaining luminescence for photographic purposes. The apparatus to be described in the present article is similar in principle to the one just mentioned, but carries a number of improvements which make it much more convenient and efficient. By means of this apparatus, the light may be maintained automatically and may be controlled. The name,

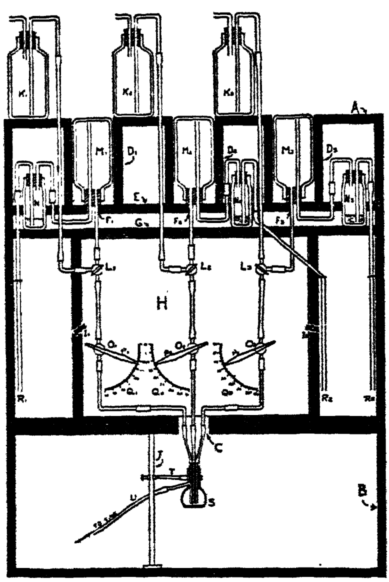

Fig. 1. Diagrammatic drawing of the Lumistat.

"Lumistat", is suggested as an appropriate one, since its purpose is "automatically to control luminescence". It is inexpensive to construct, and is so made that it can be taken apart for transportation purposes.

[1] J. Chem. Ed., 1939 **16**:292-4.

[2] Cottman, (1937), J. Chem. Ed., **14**:236-7.
Cottman, (1939), J. Chem. Ed., **16**:292-4.
Cottman, (1939), Sci. American, **160**:364-6.
Cottman, Moffett and Moffett, (1938), Proc. Indiana Acad. Sci., **47**:124-9.
Cottman, Moffett and Moffett, (1939), Proc. Indiana Acad. Sci., **48**:77-8.

The writer has found it very satisfactory in maintaining an almost constant chemiluminescence over long periods of time, using the solutions described in various preceding articles[2]. A diagramatic drawing is presented in Figure 1, for which the following explanation is given:

The framework, which is of wood, consists of an upper chamber, A, which is set directly above a lower chamber, B. A is 40" x 40" x 12". B is 40" x 24" x 12". A hole, C, in the bottom of A, coincides with a hole in the top of B. Three pockets, D_1, D_2, and D_3 are built of such a size that each will hold a five pint bottle. A shelf, E, 4" wide, is built as a support for the bottles M_1, M_2, M_3. Three notches, F_1, F_2, F_3, each ½" in width, are cut back into E as shown, so as to allow the tubes from the bottles to extend downward through E. Another shelf, G, 6" wide, extends across the apparatus to support the bottles N_1, N_2, N_3. H is the control panel. It is a board, 24" x 24", which can be removed from the rest of the framework. When mounted in the apparatus, it is held in place by the turn-buttons, I_1, I_2. B is fitted with an iron ringstand rod, J.

The solutions used in the chemiluminescence reactions are made up in the large supply bottles, K_1, K_2, K_3. These are connected to the three-way stopcocks, L_1, L_2, L_3, which are mounted on the panel board, H. M_1, M_2, M_3 are the reservoirs which are filled by siphoning from K_1, K_2, K_3 through the three-way stopcocks, as shown. Connected to the long air tubes of M_1, M_2, M_3, are the "bubble bottles", N_1, N_2, N_3, which are partially filled with water, so as to cover the lower end of the long tube in each. O_1, O_2, O_3 are two-way stopcocks which are mounted on the control panel, H. Attached to the tops of these stopcocks are the wooden levers, P_1, P_2, P_3, each 6" in length. To fit these to the stopcocks, a depression should be carved into the under side of the lever, into which depression the upper convex surface of the stopcock handle will fit. The wood and glass may then be cemented together with Apiezon wax. Extending down from the ends of the levers are steel pointers of moderate flexibility. Q_1, Q_2, Q_3 are the scales for marking the positions of the pointers. To prepare these scales, the arcs described by the pointers should be marked in pencil, then brass brads with rounded heads should be driven in along this arc very close to each other. This will make an arc having a "stop" between each two brad heads. The flexible steel pointers should be of such a length as to slide over this arc. The "stops" should be numbered as shown. These numbers are arbitrary, but will serve as a means of marking the positions of the pointers and will indicate the rate of flow of the liquids. If P_1, P_2, P_3 are each marked with a streak of phosphorescent paint, this will aid in finding them in the dark.

The "bubble bottles" N_1, N_2, N_3, are equipped with long rubber "listening tubes", R_1, R_2, R_3, which are held in place as shown, with screw-eye guides. As the solutions flow down from the reservoirs M_1, M_2, M_3, bubbles of air will be drawn through the water traps of N_1, N_2, N_3. The operator can then, in complete darkness, know with certainty whether each solution is feeding properly and how rapidly it is flowing, by simply placing the ends of the tubes R_1, R_2 and R_3 to his ears and listening to the bubbles.

The tubes from the three reservoirs all lead into the reaction chamber, S, which is a small distilling flask supported by a clamp, T. Here the liquids mix, producing chemiluminescence, which may then be photographed or otherwise studied. The used liquids escape through the overflow tube, U.

To operate the lumistat requires the following procedures:

1. K_1, K_2, K_3 are filled with the required solutions.

2. Stopcocks L_1, L_2, L_3 are turned so as to connect K_1, K_2, K_3 to M_1, M_2, M_3.

3. The rubber stoppers of N_1, N_2, N_3 are loosened so that air will be admitted at the mouths of these bottles.

4. Air is blown into K_1, K_2, K_3, which will cause the solutions to siphon into M_1, M_2, M_3. A source of compressed air will, of course, speed up this siphoning.

5. When M_1, M_2, M_3 are nearly filled, L_1, L_2, L_3 are turned so as to connect M_1, M_2, M_3 with the control stopcocks O_1, O_2, O_3. The stoppers are then replaced tightly in N_1, N_2, N_3.

6. The room is darkened and the pointers P_1, P_2, P_3 are carefully adjusted until the maximum luminescence is obtained. This adjustment is sometimes critical, but once obtained, can be immediately duplicated at a later time for any given set of solutions.

7. If anything should go wrong so that the luminescence is extinguished or reduced, the source of trouble may usually be located by listening through R_1, R_2, and R_3.

8. When M_1, M_2, M_3 are filled, there will be sufficient solution to keep the lumistat operating continuously for about an hour. During this time, K_1, K_2, K_3 may be removed and refilled if necessary.

9. If desired, L_1, L_2, L_3 may be so turned as to connect the supply bottles K_1, K_2, K_3 directly with the control levers. This, however, will cut out the bubble bottles.

10. Care should be taken that no liquid should collect in the long air tubes leading into M_1, M_2, M_3. If this occurs, the flow of liquid from the reservoirs will be uneven.

The Preparation and Dehydration of Some Phenyl-Substituted Ethylenic Carbinols

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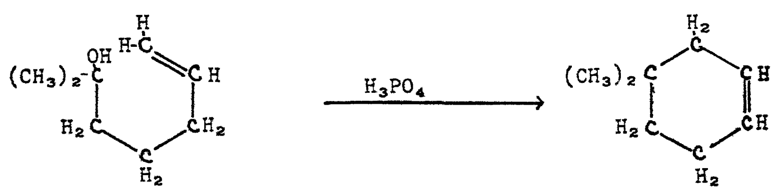
University of Notre Dame

The dehydration of alcohols is one of the most widely studied fields in organic chemistry. Almost all types of alcohols have been dehydrated, and a large variety of dehydrating agents have been used. Ordinarily the product of dehydration is an olefin, although sometimes an ether is formed, and more rarely a cyclic hydrocarbon. It is with this last type of dehydration that the present paper is concerned.

The conversion of an open-chain alcohol to a cyclic hydrocarbon is usually brought about by acid reagents, especially sulfuric acid and phosphoric acid. As a rule, simple aliphatic saturated alcohols do not yield cyclic products on acid dehydration, they form olefins which may or may not polymerize. With unsaturated aliphatic alcohols the picture is somewhat different. Normal dehydration yields a diolefin, which may polymerize, or may rearrange to a cyclic compound, or direct cyclodehydration may occur. As an example the work of Hibbit and Linstead[1] may be cited. These workers found that 2-methyl-6-hepten-2-ol (I) on treatment with phosphoric acid yielded a cyclohexene derivative, II,



I II

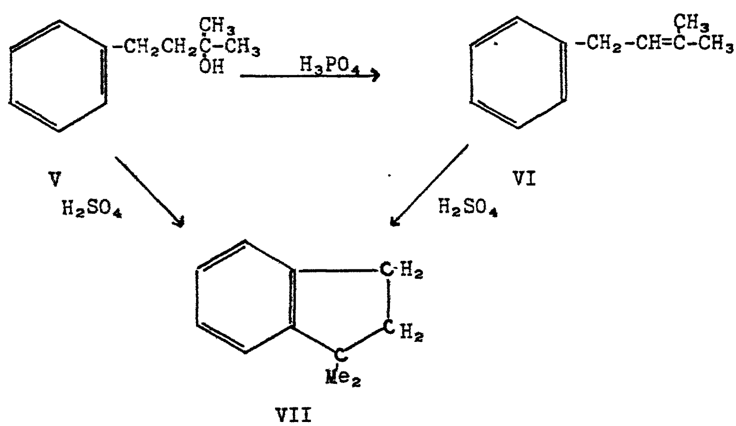
presumably by direct ring closure, but in the case of 1-butenyl-2-methyl cyclohexanol (III), the initial dehydration product was an open chain diolefin, which on prolonged heating with the dehydrating agent rear-

III IV

[1] Hibbit, D. C., and Linstead, R. P., 1936. J. Chem. Soc., 470.

ranged to a cyclic product, IV. Exactly what structural relations are necessary to obtain ring closure from unsaturated alcohols has not been determined, for Hibbit and Linstead found that many ethylenic alcohols closely related structurally to the two cases cited yielded only diolefins which could not be cyclized. When cyclic products were formed, they always contained five or six carbon atoms in the ring.

Bogert and Davidson[2] have made a detailed study of the acid dehydration of phenyl-substituted saturated alcohols. They found that these alcohols on treatment with concentrated sulfuric acid yielded olefin polymers or cyclic hydrocarbons (indanes and tetralins), and they also showed that the olefins were intermediate in the formation of the cyclic hydrocarbons. As an illustration, 4-phenyl-2-methyl-2-butanol (V) when treated with phosphoric acid yielded 4-phenyl-2-methyl-2-butene (VI) but when either the carbinol or the olefin was treated with sulfuric acid, 1,1,-dimethylindane (VII) was obtained. These workers found that no



ring closure ever occurred when the hydroxyl group was on the same carbon atom as the phenyl group. The other structural requirements necessary for ring closure have not been definitely determined.

No study has been made heretofore, as far as we are aware, of the dehydration of phenyl-substituted unsaturated alcohols. In this paper we are reporting the preparation of three phenyl-substituted ethylenic alcohols, namely, 1-phenyl-1-hydroxy-2-heptene, C_6H_5–CHOH–CH=CH–C_4H_9; 1-phenyl-3-hydroxy-1-butene, C_6H_5–CH=CH–CHOH–CH_3; and the cis and trans forms of 1,3-diphenyl-3-hydroxy-1-propene, C_6H_5–CH=CH–CHOH–C_6H_5; and a study of the dehydration of these alcohols with phosphoric acid.

With the exception of the trans form of 1,3-diphenyl-3-hydroxy-1-propene, these carbinols were made by treating an acetylenic Grignard reagent with a suitable aldehyde, and reducing the acetylenic carbinol

[2] Bogert, M. T., and Davidson, D., 1934. Jour. Am. Chem. Soc., 56:185.

with hydrogen in the presence of Raney nickel to the ethylenic carbinol. This type of reduction has been shown to yield cis olefins.[3]

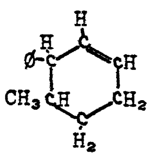
$$C_6H_5C{\equiv}CH + C_2H_5MgBr \longrightarrow C_6H_5C{\equiv}CMgBr \xrightarrow{CH_3CHO}$$

$$C_6H_5C{\equiv}C\text{–}CHOH\text{–}CH_3 \xrightarrow[\text{Raney Ni}]{H_2} C_6H_5\text{–}CH{=}CH\text{–}CHOH\text{–}CH_3.$$

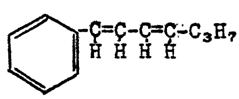
The trans form of 1,3-diphenyl-3-hydroxy-1-propene was made from cinnamic aldehyde (in which the double bond has the trans configuration) and phenylmagnesium bromide.

Attempts were made to dehydrate these carbinols with sulfuric acid, but only tarry polymers resulted. Phosphoric acid proved to be more satisfactory, although even here large amounts of polymers were formed.

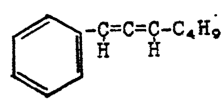
The dehydration of 1-phenyl-1-hydroxy-2-heptene could occur in any of several ways, to yield a cyclic compound (VIII), or a diolefin, in which the double bonds could be conjugated (IX), cumulated (X), or isolated



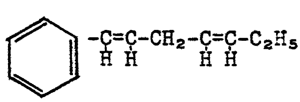
VIII



IX



X

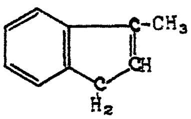


XI

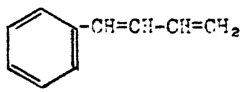
(XI). The product obtained had a molecular weight in agreement with any of these possibilities, and was unsaturated. A parachor determination gave a value of 457. The parachor calculated for a cyclic compound of formula VIII is 441, while the calculated parachor for any of the diolefins is 458. This result would seem to eliminate the cyclic structure VIII from consideration. Quantitative microhydrogenation showed the presence of two aliphatic double bonds, thus providing additional evidence that the product did not have structure VIII. The hydrocarbon reacted readily with maleic anhydride to give a well-defined crystalline product. Since in general maleic anhydride reacts only with conjugated diolefins, the aggregate of the data establishes formula IX, 1-phenyl-1,3-heptadiene, as that of the dehydration product. The molecular refraction (61.4) is in agreement with this structure, since it shows a high optical exaltation (calculated, 56.0).

[3] Campbell, K. N., and Eby, L. T. 1940. Jour. Am. Chem. Soc., 62, December.

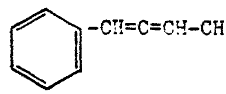
Dehydration of 1-phenyl-3-hydroxy-1-butene, $C_6H_5CH{=}CH{-}CHOH{-}CH_3$, could yield a cyclic compound, methylindene (XII), a conjugated diolefin, phenyl-1,3-butadiene (XIII) or a cumulated diene (XIV), although this latter is unlikely. The molecular weight was in agreement with any of these possibilities. The parachor was found to be 326, while the value calculated for methylindene (XII) is 326.4, and for either diene, (XIII or XIV) is 331. The substance on quantitative micro-



XII



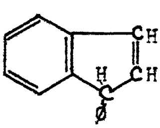
XIII



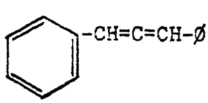
XIV

hydrogenation showed the presence of but one double bond. These data establish the fact that dehydration of this carbinol yields a cyclic substance, a methylindene, XII.

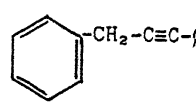
The cis and trans forms of 1,3-diphenyl-3-hydroxy-1-propene, $C_6H_5{-}CH{=}CH{-}CHOH{-}C_6H_5$, yielded the same unsaturated hydrocarbon. This could have any of the following structures: phenylindene (XV), diphenylpropadiene (XVI) or phenylbenzylacetylene (XVII). The parachor was



XV



XVI



XVII

found to be 478, while the value calculated for phenylindene is 461, and for the open-chain compounds is 475. Quantitative micro-hydrogenation showed absorption of four atoms of hydrogen, thus eliminating phenylindene (XV) from consideration. The evidence is not sufficient to distinguish between the allene XVI and the acetylene XVII.

Experimental Part

Preparation of 1-Phenyl-1-hydroxy-2-heptene.—n-Butylethinylmagnesium bromide was prepared by treating ethylmagnesium bromide (from 21.5 g. of magnesium, 109 g. of ethyl bromide and 400 cc. of ether) with 59.6 g. of n-butylacetylene in an equal volume of dry ether. The reaction flask was then packed in an ice-salt bath, and a solution of 74 g. of redistilled benzaldehyde in 75 cc. of dry ether was added drop-wise during the course of two hours. The mixture was allowed to warm up to room temperature, and was then hydrolyzed with ice and ammonium chloride. The organic layer and ether extracts were dried over magnesium sulfate, and the residue left after evaporation of the ether was

distilled under reduced pressure to yield 81 g. (62%) of 1-phenyl-1-hydroxy-2-heptyne, b.p. 152°/8 mm., n_D^{20}: 1.5268, d_4^{20}: 0.9950, MR_D obs. 58.20, MR_D calc'd., 58.0.

One gram (wet weight) of Raney nickel catalyst was added to a solution of 39 g. (0.21 moles) of the acetylenic carbinol in 100 cc. of absolute methanol, and the mixture was shaken with hydrogen at an initial pressure of 4 atmospheres until 0.21 moles had been absorbed. The methanol was removed from the filtered reaction product by distillation, and the residue dried over magnesium sulfate and distilled under reduced pressure. A 63% yield of ethylenic carbinol was obtained, b.p. 150°/7 mm., n_D^{20}: 1.5142, d_4^{20}: 0.9514, MR_D obs. 59.67, MR_D calc'd, 59.7.

Dehydration of 1-Phenyl-1-hydroxy-2-heptene.—A mixture of 50 cc. of 85% syrupy phosphoric acid and 11 g. of the carbinol was heated on the steam bath for thirty minutes, and was then steam-distilled under reduced pressure. The organic layer so obtained was dried and redistilled to yield 7.8 g. (75%) of a viscous yellow liquid, b.p. 122°/8 mm., n_D^{20}: 1.5643, d_4^{20}: 0.9122, MR_D obs. 61.4. This product decolorized bromine in carbon tetrachloride and was oxidized by aqueous alkaline potassium permanganate in the cold. It gave negative tests for phosphorus, carbonyl and hydroxyl groups.

Mol. Wt. (cryoscopic in benzene). Found, 179.0, calc'd for $C_{13}H_{16}$, 172.
Parachor. Surface tension (maximum bubble-pressure method),[4] 34.84 dynes/cm. P, found, 475.4 P, calc'd for 1-phenyl-1,3-heptadiene, 458.1, P, calc'd for phenylmethylcyclohexene, 441.
Quantitative Hydrogenation.—1.3537 g. (0.007 moles) required 0.014 moles of hydrogen for saturation, using Raney nickel as catalyst and methyl alcohol as solvent.

Reaction with Maleic Anhydride.—One gram of the compound was heated with 1.5 g. of maleic anhydride for ten minutes. The product on recrystallization from high-boiling ligroin and benzene was obtained as white crystals, m.p. 62°. Mol. Wt., found, 266, calc'd for $C_{17}H_{14}O_3$, 266. Saponification equivalent, found, 146, calc'd for $C_{17}H_{14}O_3$, 142.

Preparation of 1-Phenyl-3-hydroxy-1-butene.—Phenylethinylmagnesium bromide was prepared from 0.8 moles of ethylmagnesium bromide and 71.5 g. of phenylacetylene. The reaction flask was immersed in a salt-ice bath and a solution of 26.4 g. of acetaldehyde in three volumes of dry ether was added very slowly. The mixture was worked up in the usual way, and gave a 63% yield of 1-phenyl-3-hydroxy-1-butyne, b.p. 128°/ mm., n_D^{20}: 1.5662, d_4^{20}: 1.0664, MR_D obs. 45.4, MR_D calc'd. 45.0. A solution of 28.9 g. (0.198 moles) of the acetylenic carbinol in 50 cc. of methanol containing 1 g. of Raney nickel required three minutes to absorb 0.198 moles of hydrogen. The 1-phenyl-3-hydroxy-1-butene, obtained in 50-60% yields, had the following properties: b.p. 118°/12 mm., n_D^{20}: 1.5388, d_4^{20}: 1.0050, MR_D obs. 46.1, MR_D calc'd. 45.8.

[4] Sugden, S., 1930. "The Parachor and Valency," First Edition, p. 131.

Dehydration of 1-phenyl-3-hydroxy-1-butene.—Thirty-five grams of the carbinol was treated as described above, with 100 cc. of phosphoric acid. Considerable tar was formed, and only a 10% yield of hydrocarbon was isolated. The product had the following properties: b.p. 94°/10 mm., n^{20}_{D}: 1.5956, d^{20}_{4}: 1.0422. MR_D obs. 42.3, MR_D calc'd for methylindene, 42.1.

Mol. Wt. (cryoscopic). Found, 132.0, calc'd. for $C_{10}H_{10}$, 130.
Parachor. Surface tension, 47.1 dynes/cm. P, obs. 326.0 P, calc'd. for methylindene, 326.4, P, calc'd. for phenylbutadiene, 331.1.
Quantitative hydrogenation. 0.0079 moles of compound absorbed 0.0079 moles of hydrogen.

Preparation of trans 1,3-Diphenyl-3-hydroxy-1-propene.—A solution of 110 g. (0.9 moles) of redistilled cinnamaldehyde in two volumes of dry ether was added during the course of five hours to one mole of phenylmagnesium bromide, cooled in an ice-salt bath. The product, isolated in the usual way, was obtained as a white solid (yield, 63%), which melted at 55° after four recrystallizations from ligroin-carbon tetrachloride.

Mol. Wt. (cryoscopic). Found, 200. Calc'd. for $C_{15}H_{14}O$, 210.

Preparation of cis 1,3-Diphenyl-3-hydroxy-1-propene.—Phenylethinylmagnesium bromide, made from 66 g. of phenylacetylene and 0.7 moles of ethylmagnesium bromide, was cooled in an ice-salt bath and treated with a solution of 52 g. of redistilled benzaldehyde in 50 cc. of dry ether. The acetylenic carbinol was obtained as a very viscous liquid, b.p. 180°/5 mm., n^{20}_{D} 1.5842. A solution of 30 g. (0.13 moles) of undistilled acetylenic carbinol in 50 cc. of methyl alcohol containing 1 g. of Raney nickel was treated with hydrogen until 0.13 moles had been absorbed. The cis 1,3-diphenyl-3-hydroxy-1-propene so obtained had the following properties: b.p. 158-160°/4 mm., n^{20}_{D}: 1.5821, d^{20}_{4}: 1.0638., MR_D obs. 60.8, MR_D calc'd., 63.3.

Dehydration of 1,3-Diphenyl-3-hydroxy-1-propene.—The cis and trans carbinols on treatment with syrupy phosphoric acid in the usual way apparently yielded the same unsaturated hydrocarbon, together with considerable tar. The physical properties are as follows:

Product from cis carbinol, b.p. 130-133°/4 mm., n^{20}_{D}: 1.6045, d^{20}_{4}: 1.0252, MR_D obs. 64.4, MR_D calc'd. for phenylindene, 61.6. MR_D calc'd. for phenylbenzylacetylene or diphenylpropadiene, 63.3. Mol. Wt. (cryoscopic), found, 194, calc'd. for $C_{15}H_{12}$, 192.

Product from trans carbinol, b.p. 145-150°/8 mm., n^{20}_{D}: 1.6045, d^{20}_{4}: 1.0248, MR_D obs. 64.4. Mol. Wt. (cryoscopic), found, 196.

Johnson and co-workers[5] report the following for phenylbenzylacetylene: b.p. 128-129°/2 mm., n^{20}_{D}: 1.5946, d^{20}_{4}: 1.0273.

[5] Johnson, J. R., Jacobs, T. L., and Schwartz, A. M., 1938. Jour. Am. Chem. Soc., 60:1885.

Quantitative hydrogenation: 1.0025 g. (0.0075 moles) required 0.015 moles of hydrogen for saturation.

Parachor. Surface tension, 41.98 dynes/cm. P, obs. 478, P, calculated for phenylindene, 461.3 P, calculated for diphenylpropadiene or phenylbenzyl acetylene, 475.

Summary

Three new phenyl-substituted ethylenic alcohols have been prepared, and their dehydration with phosphoric acid studied. Formulas have been proposed for the dehydration products.

A Consideration of the Concepts of Relative Electronegativity

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The concept of relative electronegativity, as applied to organic chemistry, was first observed by Markovnikov in 1870 while studying the addition reactions of the olefin bond. At that time he formulated his observations into a rule which has since come to bear his name. An English translation of his original statement reads: "When an unsymmetrically constituted hydrocarbon combines with a halogen acid, the halogen of the acid adds on to the less hydrogenated carbon atom, that is, to the carbon atom which is under the influence of the other carbon atoms" (1). Somewhat later he stated that the addition of halogen acid to "vinyl chloride, chloropropylene, and other analogs" takes place so that the halogen of the acid becomes bonded to the carbon atom that already supports a halogen atom.

Wagner and Saytzeff observed that in the addition of halogen acids to olefins of the type R·HC:CH·R′, where R′ is lighter than R, the halogen of the acid becomes bonded to the carbon atom which is linked to the lighter alkyl radical (2).

In 1899 Michael evidenced a better understanding of this phenomena in his statement that "every system tends toward that state whereby the maximum chemical neutralization is reached." To show that this applied to addition reactions of the olefin bond he treated propylene with both iodochloride and bromochloride to give the results indicated by the equations (3):

$CH_3{\cdot}HC{:}CH_2 + I{\cdot}Cl \rightarrow CH_3{\cdot}CHCl{\cdot}CH_2I$ (3 parts) $+ CH_3{\cdot}CHI{\cdot}CH_2{\cdot}Cl$ (1 part), and $CH_3{\cdot}HC{:}CH_2 + Br{\cdot}Cl \rightarrow CH_3{\cdot}CHCl{\cdot}CH_2{\cdot}Br$ (7 parts) $+$ $CH_3{\cdot}CHBr{\cdot}CH_2{\cdot}Cl$ (5 parts).

The results clearly indicate that some kind of an electrical effect is involved, for the three-to-one ratio in the first equation becomes a seven-to-five ratio in the second equation.

During the next forty years a number of workers contributed to progress in this field. Ipatieff observed that temperature, solvent, and other factors effect the ratio of end products of any given reaction (4). Lapworth proposed his theory of "alternate latent polarities"(5) and both Biach and Cuy cited physical data pertaining to melting points, heats of crystallizations, heats of combustions, and molecular volumes in confirmation of this postulate (6, 7). These workers visualized the organic molecule as being composed of a chain of carbon atoms in which there is a decided tendency for alternate atoms to be positively charged with the corresponding negative charges on the intervening atoms. It has been argued, however, that the concept is not valid since no corresponding irregularity is observed with respect to the boiling points, refractive indices, molecular volumes, and other properties of these same homologous series (8, 9).

Lewis, in 1923, postulated that the olefin bond is best represented by:

$$H:\overset{\overset{H}{\cdot\cdot}}{C}::\overset{\overset{H}{\cdot\cdot}}{C}:H \text{ or } H:\underset{\cdot}{\overset{\overset{H}{\cdot\cdot}}{C}}:\underset{\cdot}{\overset{\overset{H}{\cdot\cdot}}{C}}:H \text{ or an intermediary form.}$$

Carothers (1924) extended the Lewis formulation to include two active and one inactive form, as represented by (10):

$$H:\underset{\cdot\cdot}{\overset{\overset{H}{\cdot\cdot}}{C}}:\overset{\overset{H}{\cdot\cdot}}{C}:H \rightarrow H:\overset{\overset{H}{\cdot\cdot}}{C}::\overset{\overset{H}{\cdot\cdot}}{C}:H \rightarrow H:\overset{\overset{H}{\cdot\cdot}}{C}:\underset{\cdot\cdot}{\overset{\overset{H}{\cdot\cdot}}{C}}:H.$$

active form inactive form active form

Stieglitz recognized the phenomena of relative electronegativity for he employed "the direction of the addition of a halogen acid as the criterion for the determination of the relative electronegativities of the two carbon atoms joined by a double bond" (11). This idea has been extended by Lucas (12), by Kharasch (13), by Ingold (14), and others, but each has used his own method for assigning relative electronegativities. With these contending concepts in the literature, Pauling developed his Electronegativity Map which offers another method of assigning relative electronegativities to the constituent atoms of an organic molecule (15).

There are, consequently, at the present writing, four viewpoints that must receive some consideration, namely, that of the doubters, that of Lucas, that of Kharasch, and that of one of the authors of this paper.

Referring to the doubters, it must be conceded that there are organic chemists who still cling to the belief that (a) relative electronegativity does not manifest itself in organic compounds, or (b) its application is beyond the realm of feasibility. Aside from the directive addition to unsymmetrical olefin bonds, the development of the Pauling Electronegativity Map, if it is correctly interpreted, seems to afford ample evidence for the Electronegativity concept as a working hypothesis in organic chemistry. Experimental data points more and more to the belief that the essential difference between an organic reaction and an analogous inorganic reaction is one of degree rather than one of type. Sodium hydroxide, for example, reacts with hydrochloric acid to give sodium ion, chloride ion, and water, and sodium acetylide reacts similarly to give sodium ion, chloride ion, and acetylene. The essential difference between the sodium-chlorine bond in the former and the sodium-carbon bond in the latter is one of degree rather than one of type.

The Lucas (16) postulate differs from the original Lapworth (17) concept in that the former considers an inductive effect in lieu of the alternate polarity concept, as illustrated by:

$$H\ \ :\underset{\underset{H}{\cdot\cdot}}{\overset{\overset{H}{\cdot\cdot}}{C}}\ \ :\underset{\underset{H}{\cdot\cdot}}{\overset{\overset{H}{\cdot\cdot}}{C}}\ \ :\overset{\overset{O}{:\,:}}{C}\ \ :O\ \ :H \quad \text{versus} \quad H:\ \underset{\underset{H}{\cdot\cdot}}{\overset{\overset{H}{\cdot\cdot}}{C}}\ :\underset{\underset{H}{\cdot\cdot}}{\overset{\overset{H}{\cdot\cdot}}{C}}:\ \overset{\overset{O}{:\,:}}{C}\ :O:\ H, \text{ or}$$

$$CH_3^+ \;\; -CH_2^+ \;\; -CO^+ \;\; -OH \quad \text{versus} \quad CH_3^+ \;\; -CH_2^- \;\; +CO^+ \;\; -OH.$$

inductive effect of Lucas *alternate polarity effect of Lapworth*

Lucas arrives at the relative electronegativity of the various radicals by a consideration of the ionization constants of the acids, alcohols, phenols, and other compounds. There is, for example, a decrease in acidity in passing from acetic through propionic to butyric acid, hence Lucas argues that the order of decreasing electronegativity is methyl, ethyl, propyl. This system of measuring relative electronegativity is independent of the addition of halogen acids to olefin bonds and has, consequently, value that must not be disposed of too lightly. The idea of a lop-sided electrical charge, on the other hand, seems to be opposed to the general tendency of an electrical charge to be distributed symmetrically. The electrons tend to form completed octets and to take up positions at the corners of an imaginary tetrahedron because by so doing they are distributing themselves symmetrically about the atom concerned. To the writers it seems unlikely, in view of our present concepts of the behavior of electricity, that one side of an atom will carry a positive charge whereas the other side will carry a negative charge. It should be pointed out, moreover, that the Lucas postulate like the Lapworth concept is dependent on key atoms or groups for the direction of the displacement, but the former theory does provide a means for deciding between two or more contending forces.

Kharasch has developed the Stieglitz concept by actually using the addition of halogen acids to olefins to determine the relative electronegativities of the residues concerned. In the addition, for example, of H·X to R·HC:CH·R′ the direction of addition is noted and it is reasoned that the X group becomes bonded to the more electropositive carbon atom of the olefin pair hence the alkyl residue attached to this particular carbon atom is more strongly electronegative or electron attracting than is the other substituent alkyl group. If, to cite a specific case, 2-pentene is treated with hydrogen chloride, the principal reaction takes the course:

$$CH_3{\cdot}CH_2{\cdot}HC{:}CH{\cdot}CH_3 + HCl \rightarrow CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CHCl{\cdot}CH_3.$$

This is interpreted by Kharasch as meaning that the methyl group is more electronegative than is the ethyl group, and on this basis, by varying the substituents, he has built up a relative electronegativity series (18). The main disadvantage of this system, as the authors of this paper see it, are that (1) one is reasoning in a circle, and (2) the system has definite limitations. That is, one uses a reaction to test out the relative electronegativities of the radicals and then cites the directive addition as proof for the relative electronegativities of the carbon atoms concerned. In the second place, the system deals only with compounds containing olefinic linkages and hence limits its application to a very small field of organic chemistry.

The system proposed by one of us is a direct application of the Electronegativity Map of Linus Pauling. This table, in an *abridged* form for the purpose of this discussion, places the H atom at 2.1, the carbon, sulfur, and iodine atoms at 2.5, the bromine atom at 2.8, the nitrogen and chlorine atoms at 3.0, and the oxygen atom at 3.5, as indicated by Table I:

TABLE I. Abridged Form of the Pauling Electronegativity Map, Expressed in Volt Electrons

1.0	1.5	2.0	2.5	3.0	3.5	4.0
+ ←						→ −
		H 2.1				
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
			S 2.5	Cl 3.0		
				Br 2.8		
			I 2.5			

From this map it is seen that the hydrogen atom lies on the metallic or electropositive side of the carbon atom, whereas the bromine, nitrogen, chlorine, oxygen, and fluorine atoms lie to the nonmetallic or electronegative side of the carbon atom. It is observed, furthermore, that a quantitative relationship is indicated, that is, the difference between a hydrogen atom and a carbon atom is 0.4 volt electrons whereas the differences between a carbon atom and a bromine, nitrogen, chlorine, oxygen, and fluorine atoms are, respectively, 0.3, 0.5, 0.5, 1.0, and 1.5. This suggests the possibility of regarding the organic molecule as an electrostatic aristocracy, in which each constituent atom is assigned a vote on the basis of its position in the Electronegativity Map. For the sake of simplicity, each of these differences are multiplied by the factor 2.5 so as to give hydrogen a value of +1. With hydrogen at +1, the other important values are: S, 0.0; I, 0.0; Br, –0.75; N, –1.25; Cl, –1.25; and singly bonded O, –2.5. On the assumption that a doubly bonded oxygen atom should have about twice the effect of a singly bonded oxygen atom, it is given a value somewhat less than –5.0.

These values enable one to calculate the relative state of equilibrium between the two extreme forms of an electronic system such as that of propylene and acrylic acid:

$$CH_3^{-}\ {}^{+}HC^{+}_{+}\ {}^{-}_{-}CH_2 \rightleftarrows CH_3^{+}\ {}^{-}HC^{-}_{-}\ {}^{+}_{+}CH_2, \text{ and}$$

$$H_2C^{+}_{+}\ {}^{-}_{-}CH^{-}\ {}^{+}CO^{+}\ {}^{-}OH \rightleftarrows H_2C^{-}_{-}\ {}^{+}_{+}CH^{+}\ {}^{-}CO^{-}\ {}^{-}OH.$$

In the case of propylene, the left hand configuration is favored by five of the substituent hydrogen groupings and opposed by *only* one, hence it is assigned an R. E. (relative electronegativity) ratio of five to one (5/1). This means that approximately 83% of the life of this molecule is best represented by the formulation shown at the left and only 17% of its time is spent in the form shown at the right. Similarly, for acrylic acid the R. E. ratio, provided we consider only the atoms

attached directly to the carbon chain, is eight and one-half to two (8.5/2, that is 5 for doubly bonded oxygen, 2.5 for singly bonded oxygen, and 1 for the *alpha*-hydrogen atom as opposed to 1 each for the two *beta*-hydrogen atoms). This suggests that in addition reactions about 83% of the product should be that in which the negative addend becomes bonded to the *beta*-carbon atom and the remaining 17% should represent the corresponding *alpha* variety.

With respect to olefin addition, the rule has been checked qualitatively against over two hundred cases recorded in the literature with a validity of better than 95%. The rule has, moreover, been checked quantitatively against a limited number of cases, for which quantitative data are available, with a surprising degree of accuracy. In this connection, however, one should not forget that in a series of competing reactions the nature of the end product is determined by both (a) reaction rate, and (b) the comparative stability of the derived compounds.

By regarding the organic molecule, then, as an electrostatic aristocracy in which all of the atoms determine the relative distribution of the electrons, it becomes possible to predict, by the proper assignment of electrostatic votes, the relative electronegativity of each constituent carbon atom and the composite effect of such a distribution of the electrons on the course of any given reaction.

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A Survey of the Learning of Elementary Chemistry by Beginners Contrasted with the Retention and Learning by Students with Some Previous Training

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Perhaps, in the teaching profession, there is no plaint so often heard, simply or with variations on the theme, as that one which has to do with the problem of students studying a subject for which their previous training has been inadequate.

The students themselves seem to have become obsessed with the idea and especially of late with increasing frequency this writer has heard such statements as "I did not study chemistry in high school and most of the students in my class did." The implication is that it is unreasonable to expect students without previous training in chemistry to compete, during their freshman year at college, with those who had a chemistry course in high school.

Certainly, there are problems to contend with in teaching a class made up of a random mixture of students. First, there is a wide range as to native ability and general fitness for work at the college level, and superimposed upon this, the degree of preparation for chemistry specifically. Occasionally these tend to compensate, ability and ambition making up for lack of specific preparation in chemistry. There is also the reverse case where specific training has badly failed to make up for inherent weakness. The saddest cases are those of serious inability and seriously inadequate previous training. The happiest ones, it might appear, are those where there has been a coupling of excellent ability and excellent previous training. Those who have dealt with a similar situation will perhaps agree with this author in saying that the real triumph; that which brings a major thrill to student and teacher alike is represented by a high measure of success on the part of an able student who, "started from scratch". The most modest teacher, scorning to give voice to such boasting, can yet feel in his inmost heart "I taught him what he knows."

About a year ago an opportunity was provided to obtain an idea as to the value of previous training in chemistry to students taking elementary college chemistry. An examination was available which stressed topics usually presented in the first semester in chemistry courses in the high schools of Indiana.

This examination was taken by about seven hundred and fifty college students of whom approximately half had had no high school training in chemistry. These people, therefore, achieved success on the examination primarily in terms of the chemistry they had learned during about eleven weeks of first semester college chemistry.

The group with high school training in chemistry had it to rely on as well as whatever the eleven weeks of college chemistry might have added.

The nature of the examination is indicated by the outline which follows:

Part I	Distinction between Elements, Compounds and Mixtures.
Part II	Distinction between Physical Property and Chemical Property.
Part III	Distinction between Physical Change and Chemical Change.
Part IV	Balancing of Equations.
Part V	Molecular weights from formulas.
Part VI	Formulas from names.
Part VII	Matching Exercise on General Information.
Part VIII	Completion Exercise on General Information.
Part IX	Matching Exercise on Laws, etc., especially Boyles' Law, Charles' Law and Kinetic-Molecular Theory.

The data are summarized in Table I.

TABLE I

	Women			Men		
	H.S Chem.	No H.S. Chem.	Diff.	H.S. Chem.	No H.S. Chem.	Diff.
1	2	3	4	5	6	7
I	748	633	115	760	675	85
II	778	763	115	766	718	48
III	624	504	120	679	597	82
IV	668	475	193	627	467	160
V	885	812	73	881	831	50
VI	737	564	173	754	524	230
VII	671	546	125	676	525	151
VIII	574	364	210	620	425	195
IX	554	411	143	647	513	134
Sum of the differences			1267			1135

Explanation for Table I

Column 1 lists the several parts of the examination.
Column 2 gives the score made by those women students with high school chemistry.
Column 3 gives the scores made by the women students with no high school chemistry.
Column 4 shows the differences.
Columns 5, 6, and 7 show analogous data for the men.
A perfect score on any item in Columns 2, 3, 5 and 6 would be 1000.

The scores in Table I are averages based on the results from a total of 720 examinations, 377 from men and 343 from women. Of the men, 175 had high school chemistry, 202 did not. Of the women 217 had high school chemistry, 126 did not.

One is free to speculate as he may choose on the results tabulated. Analysis of the comparative achievement of men and women on each of the several parts of the examination offers food for thought.

Another comparison is of interest.

Achievement on the examination under consideration by 631 high school students from several Indiana high schools after one semester of high school chemistry gave a raw score average of 65.0.

The corresponding raw score average for 328 college freshmen with no high school chemistry but with about eleven weeks of college chemistry was 61.2.

For the 392 with the eleven weeks of college chemistry in addition to one year of high school chemistry the corresponding score was 76.0.

It should be noted that there was a time limit of 40 minutes on the examination. This writer is quite convinced that this time factor exaggerated the difference between the groups with high school chemistry and those without. A study of this time factor is in progress.

In conclusion it should be noted that David Allen and Frances Allen performed much of the tedious arithmetic which this study necessitated.

Alkylation of the Carbohydrates

III. From Test Tube to Pilot Plant

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The pioneer work in the alkylation of the carbohydrates, as far as can be ascertained, was initiated by Emil Fischer in 1895 (1). At that time he treated D+-glucose with absolute methyl alcohol in the presence of a trace of dry hydrogen chloride (0.25%), and obtained a mixture of the two monomethyl derivatives which have since come to be known as the *alpha* and *beta*-methyl glucosides. This work appears the more significant today, forty-five years later, because of the known tendency of both plants and animals to detoxicate poisonous products with which they come in intimate contact by glycoside formation. Recent studies by Denny and Miller, for example, indicate that when potato tubers and gladiolus corms are treated with ethylene chlorohydrin, the foreign chemical is converted to a gentiobioside (2).

The foundation laid by Emil Fischer was soon taken advantage of by Irvine and Purdie. They treated the methyl alpha-D+-glucoside of Fischer with methyl iodide in the presence of silver oxide by refluxing the mixture together for a number of hours, and obtained methyl 2,3,4,6-tetramethyl-alpha-D+-glucoside, which they reported in 1903 (3). This suggested to them the possibility of using the alkylated sugars in structural studies and ushered in a research program which, in the hands of numerous investigators, has clarified materially the structure of the so-called simple sugars.

Haworth, a product of the Irvine school, sought a more economical and simpler method of effecting alkylation, and was able to report in 1915 that the alkylated derivatives of the glycosides could be obtained quite readily by the use of alkyl sulfates. (4) He treated methyl glucoside, for example, simultaneously with methyl sulfate and concentrated sodium hydroxide by the dropwise addition of the reagents to a solution of the glucoside, under vigorous agitation, at a temperature of about 80° C., until alkylation was fairly complete. The resulting mixture was extracted with chloroform, the extract dried, the solvent evaporated, and the residue realkylated under similar conditions until analysis showed complete alkylation.

The Haworth method was developed by Green and Lewis who, in 1928, reported that they had treated methyl alpha-D+-mannoside with methyl sulfate in the presence of sodium hydroxide to give methyl 2,3,4,6-tetramethyl-alpha-D+-mannoside (5). They perfected a detailed procedure, furthermore, for the hydrolysis of the mannoside to 2,3,4,6-tetramethyl-D+-mannose and for the purification of the latter product by continuous extraction with petroleum ether.

Six years later (1934) West reported that a method had been introduced whereby the sugars instead of the glycosides could be used

as the starting materials for these alkylations (6). He and his co-workers treated D+-glucose with a carbon tetrachloride solution of methyl sulfate and then with an aqueous solution of sodium hydroxide at a temperature of about 60° C. to effect glucoside formation. By continued treatment, then, by the procedure of Haworth they effected complete methylation to give methyl 2,3,4,6-tetramethyl-alpha-D+-glucoside. Subsequent acid hydrolysis of this product yielded 2,3,4,6-tetramethyl-D+-glucose.

In the same year (1934) Muskat reported that the alkylation of the carbohydrate materials could be effected with methyl sulfate in liquid ammonia (7).

Up to this point in this summary, attention has been given to the *methylation* of the carbohydrates only, but some progress had already been made with respect to *ethylation*. In 1925 Hess and Salsman reported the preparation of octaethylcellobiose (8). Coles, in 1932, reported that 2,3,6-triethyl-D+-glucose could be obtained from triethylcellulose, and indicated that an impure form of 2,3,4,6-tetraethyl-D+-glucose had been obtained (9). Two years later (1934) Muskat prepared and identified 3-ethylacetone-D+-glucose.

In 1936 Degering and Padgett produced methyl 2,3,4,6-tetraethyl-alpha-D+-glucoside by repeated ethylation of methyl alpha-D+-glucoside by the method of Haworth and subsequent treatment by the method of Irvine and Purdie (10). Acid hydrolysis of this product gave 2,3,4,6-tetraethyl-D+-glucose, which was described as white, slender needles, m.p. 80-2° C., with a specific rotation in ethyl alcohol of $(\alpha)_D^{20} = 95.9°$, and soluble in water, chloroform, ethyl alcohol, and ethyl ether. Starting with D+-glucose, by use of the West procedure, Degering, Binkley, and Sprang subsequently obtained ethyl 2,3,4,6-tetraethyl-alpha-D+-glucoside, and starting with methyl mannoside they obtained methyl 2,3,4,6-tetraethyl-D+-mannoside, as described in the following detailed procedure.

Preparation of Ethyl 2,3,4,6-Tetraethyl-Alpha-D-Glucoside Directly from D-Glucose

Twenty-five grams of *D*-glucose is dissolved in 15 ml. of water and added to a three-liter round-bottom flask which is equipped for vigorous agitation. Then 125 ml. of ethyl sulfate, dissolved in 125 ml. of carbon tetrachloride, is added to the glucose solution. Vigorous agitation is begun and the temperature of the bath raised to 65° C. Aqueous sodium hydroxide (8.5 N) is introduced dropwise from the dropping funnel until the carbon tetrachloride distils. This operation usually requires one and one-half hours. Sufficient sodium hydroxide (five hundred ml. of 8.5 N) is added then to neutralize the 220 ml. of ethyl sulfate which is to be added later. The temperature of the bath is raised to 80° C. and the ethyl sulfate introduced not faster than two drops per second. When the addition of ethyl sulfate is completed, the temperature of the water bath is raised to boiling and held there for thirty minutes, and the bath is then allowed to cool.

The mixture is extracted with six 100 ml. portions of chloroform, and the extracts dried with anhydrous sodium sulfate, decolored by treatment with Norite, and filtered. The chloroform is removed by distillation under diminished pressure, and a light yellow sirup of crude ethyl 2,3,4,6-tetraethyl-alpha-*D*-glucoside is obtained. The sirup may be rectified in a modified Podbielniak column to give a colorless liquid which boils at 99.8° C. at 0.2 mm. Its refractive index is 1.4462 at 25° C. The average yield is seven grams. This product, when subjected to hydrolysis, gives the 2,3,4,6-tetraethyl-*D*-glucose described by Degering and Padgett.

The optimum conditions for the second step in the ethylation of *D*-glucose were determined by making a study of the ethylation of methyl-alpha-*D*-glucoside with ethyl sulfate in the presence of aqueous sodium hydroxide. The methods of both West and Haworth were studied. The average of the best results of these studies are presented in Table I.

TABLE I. Optimum Concentration of Alkali for Alkylation

Experiment	Bath Temperature	Method of	Base Used	Yield	% Yield
1	80°C.	West	8.5 N NaOH	17g.	39.4
2	80°C.	West	12.5 N NaOH	10g.	23.2
3	80°C.	West	24.5 N NaOH	3g.	6.9
4	80°C.	Haworth	12.5 N NaOH	9g.	18.6
5	80°C.	Haworth	8.5 N NaOH	16g.	37.1

It may be concluded from Table I that, for the second step in the ethylation of *D*-glucose at about 80°C., 8.5 N approaches the most suitable concentration for the sodium hydroxide.

In 1929 Lewis and Greene succeeded in preparing crystalline 2,3,4,6-tetramethyl-*D*-mannose in pure form. The alkylation of sugars has now been extended by the authors of this paper to include the *ethylation* of methyl alpha-*D*-mannoside, by the procedure just cited for the ethylation of D+-glucose.

The Commercial Application

The year 1936 saw the first commercial application of alkylation to the carbohydrate series when the Dow Chemical Company began producing ethyl cellulose on a pilot plant scale. This product is now available under the trade name of Ethocel, and looks to a promising future in the fiber, film, and plastic trades. Little did the early workers in this tedious field realize that their efforts would be rewarded some day by the application of their art to the commercial production of alkylated derivatives of cellulose.

Some work has been carried on during this period in an attempt to alkylate starch, and studies are still in progress. The methyl, ethyl, and propyl starches have been obtained and their properties are being studied.

What more the future has in store, in the alkylation of the carbohydrates, remains to be unveiled by the research workers of tomorrow.

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Esterification in the Liquid Phase as Effected by Alumina and Ultraviolet Light[1]

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Bancroft (1) calls attention to the fact that sufficient data are available to show that ultraviolet light of suitable wavelength can produce the same results as catalysts in many instances. Berthelot and Gaudechon (2) studied the effect of ultraviolet light on various organic compounds, using a 110-volt lamp and employing temperatures of 50°-60° C. and 80°-90° C. Their work with alcohols led them to the conclusion that these compounds are decomposed by the action of ultraviolet light with the formation of gas mixtures. Pougnet (3) in 1911 found that ultraviolet rays accelerate the saponification of acetic ester by sodium hydroxide. Massol and Faucon (4) studied the absorption of ultraviolet rays by primary, secondary, and tertiary alcohols and found that the tertiary alcohols are more transparent to the rays than are the isomeric primary alcohols. Liquid-phase esterification, if sufficiently rapid, should be advantageous since lowering the reaction temperature in catalytic processes increases the yield in two ways (5): first, there is less decomposition at lower temperatures, and secondly, direct union of the two reactants occurs with the evolution of heat and hence, a lower temperature would be more favorable. The object of this investigation was to determine the effect of combinations of ultraviolet light, catalysts, and agitation on the liquid-phase esterification of various primary, secondary and tertiary alcohols with acetic acid.

Experimental

Materials. Ordinary 95 per cent ethyl alcohol was dehydrated, using one pound of anhydrous calcium oxide per liter of alcohol, refluxed for a period of four hours, and finally triple distilled to remove all traces of the oxide. The final distillate was preserved in 300 ml. ground-glass stoppered bottles to insure its being absolute. Glacial acetic acid of analytical reagent quality was purified by recrystallization and stored in ground-glass stoppered bottles. The alumina (grade A, mesh 8-14) was weighed on an analytical balance, placed in test tubes, and activated by heating in an electric oven for ten hours at 145° C. The test tubes

[1] This paper is constructed from a dissertation by Ora E. Rumple to the faculty of the Graduate School of Indiana University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Chemistry.

were then stoppered and placed in a calcium chloride desiccator until used. All alcohols except ethyl alcohol were obtained from the Eastman Kodak Company, and were used without further purification. The uranyl sulfate was obtained from A. Daigger and Company, alumina from the Aluminum Ore Company, thoria and titania from the City Chemical Corporation of New York, and Silica from Silica Gel Division, Davison Chemical Corporation, Baltimore, Maryland.

Apparatus. As a source of ultraviolet radiations, a Cooper-Hewitt mercury arc type of lamp (manufactured by the General Electric Vapor Lamp Company of Hoboken, New Jersey) was used, operating on a current strength of 2.25 amperes and 17 volts D.C. This lamp was suspended on the inside of an asbestos lined wooden box, the dimensions of which were 30 x 30 x 40 centimeters. The front of the box was covered by a removable glass plate which was also covered with asbestos except for a small circular spot in the middle through which the inside of the box could be viewed. To secure an elevated temperature in the box where the reaction chamber was located (just below the lamp), a nichrome heating coil was attached to the rear wall. A Cenco de-Khotinsky Thermo-Regulator maintained a constant (plus or minus 1° C.) temperature within the box. A 200 ml., wide-mouthed, quartz florence flask served as a reaction chamber. It was suspended directly beneath the mercury lamp by a glass rod, fastened into the stopper. The other end of this rod extended through the box and was connected on the outside to an electric motor through a system of gears. This furnished a means of agitating the chamber. The axis of rotation of the flask was about 5 cm. below the mercury arc and parallel to it. The reaction chamber was agitated by rotating at 30 r.p.m. The temperature was maintained at 47° C., plus or minus one degree.

Determination of The Intensity of Ultraviolet Light. The method of Anderson and Robinson (6) was used in the determination. The following procedure was used to determine the intensity of radiation: 25 ml. of the oxalic acid-uranyl sulfate solution was placed in a crystallizing dish having a diameter of 7.6 centimeters. The dish was suspended beneath the arc so that the surface of the liquid was 5 centimeters below it. After having been exposed to the light for three hours, the sample was removed from the box and titrated with the standard potassium permanganate solution. The average of three samples gave 68.7166 milligrams of oxalic acid decomposed for each square centimeter of surface exposed.

Procedure. The general method of procedure was to determine the amount of ester formed under the prevailing conditions of the experiment. The amount of acetic acid which had not reacted was determined by titration with standard barium hydroxide solution and the yield of ester calculated from these results.

Results and Discussion

TABLE I.—Effect of Ultraviolet Light, Alumina, and Agitation on Equal Volumes of Alcohol and Acetic Acid at 47° C.

Catalyst	Ultraviolet Light	Agitation	Time (Hrs.)	Methyl	Ethyl	Isopropyl	Sec. Butyl
....	.....	....	4	3.43	3.32%	1.49	1.50
....	.....	Agitation	4	.....	3.59	1.50	1.66
....	.....	Agitation	8	.....	7.63	2.23	1.95
Alumina	.....	....	4	3.32	3.65	2.39	3.04
Alumina	.....	....	8	4.37	3.77	3.08	3.47
Alumina	.....	Agitation	4	3.81	4.30	3.90	3.77
Alumina	.....	Agitation	8	6.47	7.15	4.89	4.88
....	Light	Agitation	4	9.15	6.86	3.59	4.49
....	Light	Agitation	8	15.30	13.21	6.34	9.11
Alumina	Light	Agitation	4	10.96	11.15	13.28	15.43
Alumina	Light	Agitation	8	14.85	13.42	14.13	16.44
Alumina	Light	Agitation	12	19.02	15.92	14.84	18.01
Alumina	Light	Agitation	24	27.50	22.26	16.98	19.88
Alumina	Light	Agitation	28	29.50	24.08	17.43	20.16
Alumina	Light	Agitation	31	30.50	25.21	17.72	20.31

Experiments were carried out with silica, thoria, titania, and alumina. Alumina was found to be the most effective.

Experiments performed with tertiary butyl and tertiary amyl alcohols gave data which were erratic. They showed no yield of ester at times, and, in some instances, a negative yield which indicates that the ratio of acid to alcohol in the mixture was increased. The reliability of esterification limits of tertiary alcohols is questionable, since these alcohols have a tendency to split off water and form unsaturated hydrocarbons.

There seems to be at least three processes involved in these esterifications: (1) the forward reaction of esterification; (2) the reverse hydrolytic reaction; and (3) the photochemical decomposition of the reactants and of the esters formed. The assumption is made that at the temperature of these reactions (47° C.) there is no thermal decomposition of any of the compounds present. If it is further assumed that photochemical decomposition occurs to an appreciable extent, the yields of ester in all instances represent a resultant of these three processes.

So far as could be learned from chemical literature, no data are available as to the comparative rate of decomposition of acetic acid and the various alcohols and esters by ultraviolet light. However, in the case of the tertiary alcohols, since at times a negative yield was obtained, it can be supposed that here the rate of esterification is slower than the rate of photochemical decomposition and that this decomposition acts to a greater extent on the alcohol, giving rise to a gaseous mixture of decomposition products and thus causing the reaction mixture to be richer in acid than it was originally.

Summary

1. The effect of ultraviolet light, alumina, and agitation on the rate of esterification of equal volumes of acetic acid and various alcohols in the liquid phase has been studied.

2. With methyl, ethyl, isopropyl, and secondary butyl alcohols ultraviolet light increased the yield in nearly all instances.

3. Photochemical decomposition may be a significant factor, particularly with tertiary alcohols.

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Heteropoly Compounds in Chemical Analysis[1]

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The word "heteropoly" was coined by Rosenheim (36) to designate the class of compounds of which ammonium molybdiphosphate is the most familiar member. Many of them have very useful analytical properties (2, 10), ranging in application from the separation of phosphorus as the insoluble ammonium molybdiphosphate to the action of molybdiphosphoric acid as an oxidation-reduction indicator. These applications have resulted in an extensive literature, as evidence of which the authors have compiled a bibliography of nearly 1,000 references dealing in some way with analytical uses. In spite of their individual applications, however, heteropoly compounds as a class have received little attention in this country. It is the purpose of the present paper to review briefly the status of heteropoly compounds and to indicate the properties and applications which are of analytical interest.

Extent of the Field. As long ago as 1826 Berzelius described the compound now known as ammonium molybdiphosphate (4), although its use in analysis was not suggested until some years later (41). Subsequent investigation disclosed other members of a class of fairly well defined complex compounds characterized by the coordination in the molecule of certain acid anhydride molecules about a central atom or group. As central atom were found most commonly phosphorus, silicon, arsenic, and boron, although titanium, manganese, zirconium, thorium, tin, lead, germanium, iodine, hafnium, and others have been listed as central atoms (10, 14, 35). Coordinating groups are most often oxides of molybdenum, tungsten, and vanadium. In summarizing the general field to 1920 Rosenheim listed 36 elements (35) in addition to oxygen which may take part in forming heteropoly anions.

The extent of the field is not limited by the number of elements which may combine to form complex anions, since variations may occur also in two other respects: (a) by variation in the ratio of coordinated groups to central atoms, and (b) by the state of oxidation of the constituent atoms. In addition, mixed crystals may be formed containing two or more coordinating groups, resulting in the formation of such compounds as the molybditungstophosphates. Two compounds closely related may also differ through isomerism or different crystal structure.

Perhaps the most important of these variations in heteropoly compounds composed of the same elements is the ratio of coordinated atoms (W, Mo, V) to central atoms (P, Si, As). This ratio is never more than 12, although it may be less, a series of well-defined 9- and 6-compounds being known. Other ratios have been reported, however, and the number

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of postulated compounds of various ratios less than 12 is very large. Wu (45) prefers to speak of the ratio of coordinated atoms or oxide groups to central oxide groups, such as P_2O_5; consequently, the nomenclature 24- and 18-acids, often found in biochemical literature, corresponds to that of the older 12- and 9-acids.

It should be mentioned that many of the compounds reported may not be true chemical individuals but mixtures of two or more compounds. Furthermore, the analytical results reported have not always been trustworthy, especially in distinguishing between water of crystallization and water of "constitution". Fortunately for analysts, the 12- and 9-series are the best defined as well as the most important analytically.

The names used now are intended to show that these compounds are derivatives of the central atom acid. This conforms to inorganic nomenclature for such compounds as fluoborates and chloroplatinates.

Structure of the Compounds. For many years it was customary to report the formula of such compounds in the form of the presumed constituent oxides, such as $3(NH_4)_2O \cdot P_2O_5 \cdot 24MoO_3 \cdot x\,H_2O$, for ammonium molybdiphosphate. Since this formulation reveals so little about the properties of the compound, and since more satisfactory proposals have been made, it seems time for analysts to abandon the old ideas. The present theories are not yet settled (28), but they seem sufficiently useful in interpreting the analytical behavior of various systems to warrant adoption until something better is available. A knowledge of the structure is of direct interest to the analyst, of course, only insofar as he may understand the necessity and method of controlling variable factors which may affect the results obtained.

Miolati (27) was probably the first to do much toward systematizing this field. His formulation, based upon Werner's coordination theory, was extended by Rosenheim (35), who assumed hypothetical parent aquo-acids, $H_{12-n}(XO_6)$, in which X is the central atom, of valence n, and the oxygen atoms may be replaced by acid radicles, such as MoO_4 or Mo_2O_7. Complete substitution of Mo_2O_7 groups, with phosphorus as the central atom, would give the formula $H_7[P(Mo_2O_7)_6]$ which becomes $(NH_4)_3H_4[P(Mo_2O_7)_6]$ for ammonium molybdiphosphate. This formulation for the 12-molybdenum compounds seemed satisfactory for interpreting the high basicity, formation in acidic solution, and ready solubility in alkalies. Table I shows other examples of Rosenheim formulations, the last two examples being 6-acids.

TABLE I.—Heteropoly Compounds

Central Atom	Valence	Parent Acid	Heteropoly Acid
B	3	$H_9(BO_6)$	$H_9[B(Mo_2O_7)_6]$
Si	4	$H_8(SiO_6)$	$H_8[Si(Mo_2O_7)_6]$
P	5	$H_7(PO_6)$	$H_7[P(Mo_2O_7)_6]$
Te	6	$H_6(TeO_6)$	$H_6[Te(MoO_4)_6]$
I	7	$H_5(IO_6)$	$H_5[I(MoO_4)_6]$

Ratios of coordinated to central atoms of less than 12 are explained by (a) assuming some unsubstituted oxygen atoms, resulting in a formula-

tion such as $H_7[PO(Mo_2O_7)_5]$, called an unsaturated compound, and (b) by the use of MoO_4 or similar groups instead of Mo_2O_7 units, resulting in a formulation such as $H_5[I(MoO_4)_6]$, called a saturated compound.

The importance of hydrogen ion concentration in the formation and stability of the compounds led Jander and his students (18) and Brintzinger (6) to study the aggregation and degradation processes involved in the formation and decomposition of the compounds. It is known, for example, that there is an optimum acidity for the successful formation of precipitates of heteropoly compounds, or of certain colored complexes of this class. This seems to indicate that more or less definite complexes persist in certain ranges of acidity. Thus, all of them are decomposed by strong alkalies, and excess strong acid seems to hinder the formation of the complexes. Middleton (26) summarized the general contributions of Rosenheim and of Jander. The variable states of aggregation postulated by Jander are a little difficult to harmonize with the definiteness of the formulations of Rosenheim or of those mentioned later (10).

Following theoretical work by Pfeiffer (32) and by Pauling (30), a recent series of X-ray studies on crystalline salts and acids by Keggin (19, 20), Illingworth and Keggin (16), Signer and Gross (38), Santos (37), Bradley and Illingworth (5), and Kraus (21) has thrown much light on the structure of the 12-compounds. Many of them have been shown to contain anions such as $[P(W_3O_{10})_4]^{---}$ and to have similar crystal structures. Attempts to prepare compounds with elements other than molybdenum or tungsten in the outer shell failed. No X-ray study of the 9- or 6-series has been made to date (1). This work has aroused considerable discussion (1, 9, 22), and it may provide the final clue to the true nature of the compounds.

Reviews of the general structural problem have been made recently by Elstner (9) and by Riesenfeld and Tobiank (34). As stated in these two papers, Rosenheim's ideas still have merit. Thus, salts of his postulated basicity, such as $(NH_4)_7[P(V_2O_6)_6]$, have been prepared. His formula for ammonium molybdiphosphate, $(NH_4)_3H_4[P(Mo_2O_7)_6]$, becomes Keggin's formula, $(NH_4)_3[P(Mo_3O_{10})_4]$, on the loss of two molecules of water. As Riesenfeld and Tobiank suggested (34), the two equilibria

$$2\,MoO_4^{--} + 2\,H^+ \rightleftarrows Mo_2O_7^{--} + H_2O$$

$$3\,MoO_4^{--} + 4\,H^+ \rightleftarrows Mo_3O_{10}^{--} + 2\,H_2O$$

indicate that the prevailing hydrogen ion concentration may determine whether the compound formed has the formula $H_3[P(Mo_3O_{10})_4]$ or $H_7[P(Mo_2O_7)_6]$. In all such compounds water of crystallization may be expected in the interstices between the anions.

Properties of Analytical Value. The properties of the heteropoly compounds which make them analytically useful are (a) insolubility of certain salts, such as potassium, cesium, rubidium, and many organic bases, (b) instability of these precipitates toward strong bases, (c) ease of reduction, (d) color of the soluble 12- and 9-series and their reduced compounds, and (e) solubility in organic solvents.

Applications. Many applications of the heteropoly compounds have been made by analysts. Complete references to all the individual uses are too numerous to be included, although a few typical or general references are cited below. The outline of kinds of applications follows the classification developed by the senior author for general quantitative methods (24).

1. **Separations.** The formation of heteropoly compounds finds considerable use as a means of accomplishing a variety of separations, usually to get the desired constituent itself in a condition susceptible to measurement. In the complex anion the elements molybdenum, tungsten and vanadium will be found in the coordinated groups, while other elements capable of such separation will form the central atom.

a. **Precipitation.** Separation by precipitation rests upon the insolubility of many heteropoly complexes. The precipitation of phosphorus as ammonium molybdiphosphate is well known (15). The separation of potassium similarly has been proposed (25). The precipitation of arsenic as molybdiarsenate is quantitative under proper conditions, while in steel analysis quinquivalent vanadium may be separated as a mixed molybdivanadophosphate. Cesium and rubidium, by virtue of the insolubility of their tungstisilicates and molybdiphosphates, may be separated from the other alkalies (29). Silver, thallous, and mercuric salts are also insoluble (17). Furman and State (13) proposed the precipitation of small amounts of phosphorus as $[Co(NH_3)_5NO_3]H[P(Mo_3O_{10})_4]\cdot H_2O$.[3] Silicon or tungsten may be precipitated as a heteropoly salt of an organic base such as nicotine, this being an example of the formation of quantitative precipitates by the interaction of heteropoly compounds with many organic bases. Methods have been based upon this fact for the determination of alkaloids, nicotine, pyridine, and other basic organic substances, many of which are precipitated as tungstisilicates. Proteins in biological substances are often precipitated with various heteropoly acids, among which have been recommended tungstiphosphoric, molybdiphosphoric, and tungstisilicic acids.

After a precipitation has been made, the precipitate may be treated in a number of different ways provided that the separation has been performed in the proper manner. Several procedures are given below.

b. **Extraction.** Extraction is a much less generally useful method of separation than precipitation. In common with many other complexes, various heteropoly acids are soluble in ether and other selected organic solvents. This property is employed not only in the preparation of the complexes, but it is the basis of the Copaux method of determining phosphorus (7). The procedure consists in shaking ether and ammonium molybdate together with the unknown. The molybdiphosphoric acid extracted in the ethereal layer may then be measured suitably, one method being by colorimetric comparison (33).

2. **Measurement.** Several different chemical characteristics of heteropoly compounds form the basis of the various specific property and

[3] More recently Horan, 1939. J. Am. Chem. Soc., **61**, 2022—claims that the formula should be $Co(NH_3)_6[P(Mo_3O_{10})_4]\ 3H_2O$.

systemic property methods of measurement now being used. The principles of these methods are outlined below, together with appropriate examples of their application.

a. **Gravimetric Methods.** In these methods the separated precipitate is (a) dried and weighed directly, the percentage of desired constituent usually being calculated by means of an empirical factor, or (b) ignited to oxides. There has been much disagreement over the merits of direct weighing. Presumably the discordant results may be attributed to indefiniteness of composition of the heteropoly compound because of failure to achieve the expected ratio of the component groups, due, perhaps, to poor control of the conditions of precipitation with the consequent production of an unsaturated compound. Also such compounds, many of which are stated to be heavily hydrated, may not dry readily to a definite degree of hydration. Still another possibility may be found in ammonium molybdiphosphate, since, according to some writers, each mole holds two moles of nitric acid which are removed with difficulty by washing.

b. **Titrimetric Methods.** The uncertainties associated with the composition of the residues weighed in gravimetric methods has led to rather general use of titrimetric procedures based upon neutralization or oxidation-reduction reactions.

a'. **Neutralimetry.** As would be expected from the fact that heteropoly compounds are composed usually of two weak acids, the complexes are stable only in acidic solution. The stability toward bases differs for individual compounds and decreases in the following order: silicates, phosphates, arsenates (containing a given coordinated group), and tungstates, molybdates, and vanadates (containing a given central atom) (26). Tungstiphosphates, for example, are formed at a higher pH than molybdiphosphates. In a mixture of phosphoric acid and sodium molybdate no proportions of the two constituents will give anything but the 6-compound. As hydrochloric acid is added, first unsaturated members of the 12-series appear and finally the saturated compound. In the case of tungstiphosphates a mixture of one mole of sodium tungstate with four moles of phosphoric acid produces 9-tungstiphosphoric acid, which addition of hydrochloric acid converts to the saturated 12-tungstiphosphoric acid (45).

Upon the addition of a base, heteropoly compounds break down according to the following type reaction:

$$2\,(NH_4)_3[P(Mo_3O_{10})_4] + 46\,NaOH \rightarrow 23\,Na_2MoO_4 + 2\,(NH_4)_2HPO_4 + 2\,(NH_4)_2MoO_4 + 22\,H_2O$$

Upon this reaction is based the Pemberton method for phosphorus which is widely employed in steel analysis. Usually an excess of standard base is added and back titrated to a definite pH. A similar method is used in the case of tungstisilicates for the determination of alkaloids or nicotine. In general, any element or compound can be determined in this way if a suitable heteropoly compound can be isolated for a neutralimetric titration.

b′. **Redoximetry.** As oxidizing agents heteropoly compounds are much stronger than their individual constituents, the molybdi- and tungsti-compounds behaving somewhat as expected from their periodic relationship to the chromates. Wu (45) reported that their sensitivity to reduction increases in the following order: 12-tungstiphosphate, 9-tungstiphosphate (two isomeric forms), 12-molybdiphosphate, and 9-molydiphosphate. Most sensitive to reduction is a mixed, unsaturated acid corresponding to a mixture of 9-molybdiphosphoric and 9-tungstiphosphoric acids. That this acid is not a mechanical mixture is shown by its increased sensitivity to reduction and by differences in other chemical properties. It is the "phenol reagent" of Folin and Denis. Benedict has used 9-tungstiarsenic acid (3) because of its similar sensitivity to reduction.

When a heteropoly compound is reduced by a mild reducing agent, the product is still a complex form of the same general type, as is evident by its precipitation with ammonia, alkaloids, and other chemical agents. Such an acid is produced by the loss of an atom or two of oxygen from each molecule. Deniges (8) gives the unsatisfying formula $(MoO_3)_4.MoO_2.H_3PO_4.4H_2O$ for molybdenum blue. Apparently the term molydenum blue is used rather loosely to include all blue reduction products of heteropoly molybdenum complexes as well as the blue oxide itself, which supposedly has the formula $(MoO_2)_2.MoO_4$ (23).

Oxidation-reduction reactions have been proposed for the determination of molybdenum, arsenic, phosphorus, and a variety of reducing agents. The determination is carried out by precipitating ammonium molybdiphosphate or molybdiarsenate which is then dissolved and reduced by metallic aluminum, copper, zinc, ferrous iron, stannous tin, or various amalgams (40). Measurements of the reduced heteropoly compound is then made by titration with a standard oxidant. The name molybdomanganimetry has been applied to a form of this process in which potassium permanganate is the titrant (12).

Molybdiphosphoric acid has been proposed as an oxidation-reduction indicator for the titration of hydrazine salts with potassium bromate solution (43).

c. **Volumetric Methods.** With materials producing only a very small amount of the heteropoly precipitate, as in the separation of phosphorus in the form of ammonium molybdiphosphate in steel analysis, attempts have been made (11, 15) to measure the volume of the precipitate after centrifuging it into a graduated capillary tube. Even if the tube is calibrated with known amounts of the desired constituent, the nature of these compounds is such that a rigid control of conditions is likely to be necessary to obtain the specific volumes requisite for reproducible results.

d. **Colorimetric Methods.** Coordinated compounds, such as nickel dimethylglyoxime, often have a color entirely different from that of any of the components. Likewise, the formation of color in the soluble heteropoly compounds may be attributed to a complex structure. Thus with silicon there is formed yellow molybdisilicic acid, $H_4[Si(Mo_3O_{10})_4]$, although none of the reactants alone shows any hue.

Certain colorimetric methods of analysis have been based upon a direct measurement of the color of the heteropoly complex produced. In the procedure for silica, referred to above, the central atom is the desired constituent (42); but in the tungstivanadophosphate method for vanadium (44) the desired constituent presumably constitutes part of the coordinated shell of the complex ion.

On reduction a number of heteropoly compounds give intensely colored reduction products, most of which are blue. This color reaction makes possible the determination of many reducing agents such as uric acid, polyphenols, proteins, adrenaline, cysteine, cystein, ascorbic acid, and reducing sugars (31). Procedures have also been proposed for inorganic reducing agents such as stannous tin, cobalt, mercury, and antimony (39). Indirect determination of many inorganic substances is possible by precipitation of the 8-hydroxyquinolate, filtration, dissolution, and determination of the 8-hydroxyquinolate by reaction with a suitable heteropoly reagent. Phosphorus, arsenic, and silicon are also determined by the blue color of the reduced heteropoly compound. Numerous reducing agents have been studied for this purpose as well as that of determining phosphorus in the presence of arsenic (39).

e. **Nephelometric Methods.** Certain nephelometric determinations are based upon the insolubility of heteropoly compounds (46). Phosphorus, arsenic, alkaloids, and nicotine are among the constituents determined in this way.

f. **Other Methods.** After separation and dissolution of the precipitated heteropoly complex, it is possible, of course, to make some other type of measurement upon the system in order to determine the desired constituent.

Summary

A brief review of the significance of heteropoly compounds in analytical chemistry is presented, including the formulations advanced by various investigators, the properties of analytical utility, and the types of applications that have been made in practical procedures.

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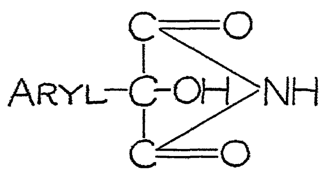
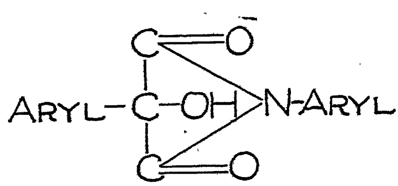
An Attempted Synthesis of n-Aryl-2,4-Diketo-3-Hydroxy-3-Arylazetidines

J. L. RIEBSOMER, THOMAS HODGSON, RICHARD REINICKE and PARK WISEMAN, DePauw University

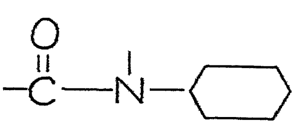
Recently we have described a method for the preparation of 2,4-diketo-3-hydroxy-3-arylazetidines,[1] (I) and reported certain pharma-

(I) 

cological studies on these compounds. It was suggested to us that it would be of interest to prepare compounds of this same type in which the hydrogen atom attached to the nitrogen was replaced by an aryl group as indicated by formula (II).

(II) 

This compound was suggested to us because it might prove to be useful as an antipyretic. This prediction was based on its structural relationship to acetanilide. In acetanilide we find the grouping

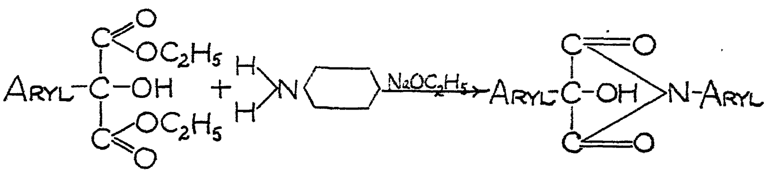


which also occurs in (II).

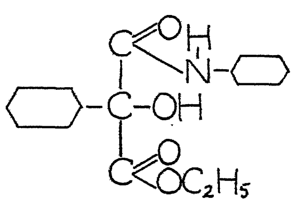
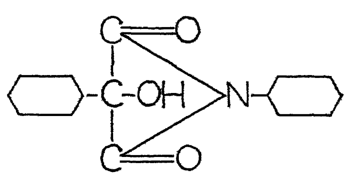
Our attempt to prepare compounds of this type was based on the experience in the preparation of type (I). The basic reaction for the preparation of type (I)[1] was to heat aryl hydroxy malonic esters with urea or ammonia gas and sodium ethylate and to follow the procedure for a typical barbituric acid synthesis.

[1] Riebsomer, Burkett, Hodgson and Senour, 1939. J. Amer. Chem. Soc., 61:3491.

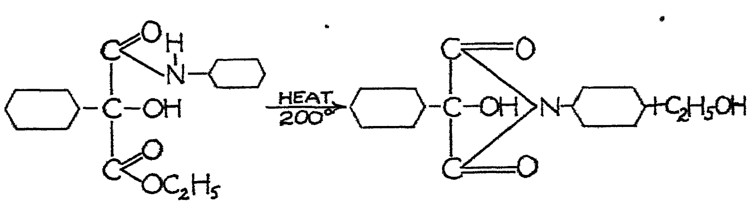
Accordingly it was predicted that if the same general procedure was followed except that aniline should be substituted for urea or ammonia that the following reactions should take place:



This reaction was carried out using phenyl hydroxy malonic ester and aniline. When the reaction product was worked up in the usual manner, a white solid was produced which crystallized readily from benzene, but which melted over a range of several degrees, usually about 145°. This indicated impurity. It seemed reasonable to suspect that the reaction had not gone to completion and that we probably had a mixture of (III) and (IV).

(III)  (IV) 

Accordingly the procedure of Tafel and Stern[2] and Dunlap[3] suggested itself for the closing of the ring by heating the mixture to 200° for 2-3 hours with the hope that (III) would react to produce (IV).



When this procedure was carried out the product was crystallized from benzene and melted sharply at 151°. But when the compound was analyzed the percentages of carbon, hydrogen and nitrogen were far too high to be the expected compound of type (II).

This compound was then saponified with potassium hydroxide. Mandelic acid and aniline were produced which would be expected from (IV) but which would also be produced from another compound, namely, the anilide of mandelic acid. The anilide of mandelic acid melts at 151°,

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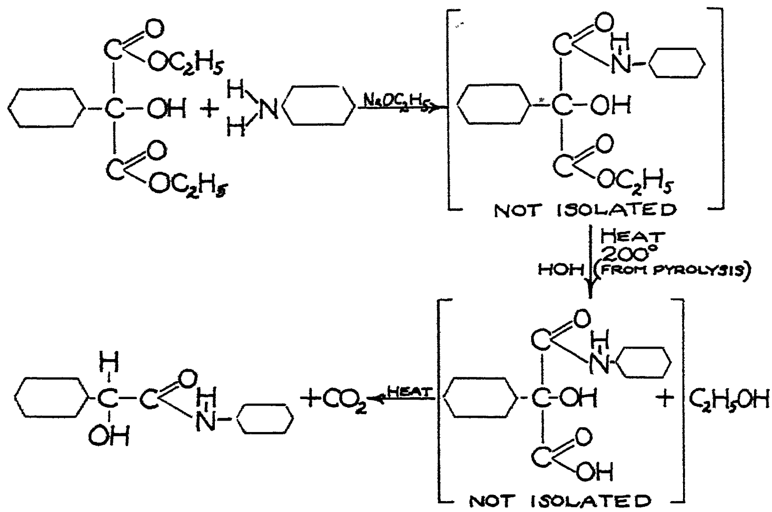
[2] Tafel and Stern, 1900. Ber., 33:2232.

[3] Dunlap, 1896. Amer. Chem. J. 18:332.

and its carbon, hydrogen and nitrogen composition checked with the analyses which we obtained for the unknown compound. A mixed melting point with the known anilide of mandelic acid showed no depression.

Therefore, the following equations are suggested to account for the reactions which actually took place:



Comparable results were obtained when p-toluidine and other aromatic amines were substituted for aniline and the same procedure was used.

It was also found that magnesium methylate when used instead of sodium ethylate as the condensing agent that the same results were produced.

Furthermore when phenyl hydroxy malonic ester and aniline were mixed using no solvent or condensing agent and heated to 200° for eight to ten hours the anilide of mandelic acid was produced, in which case the course of the reaction may be the same as indicated in the suggested equations.

Experimental Part

Reaction of aromatic amines and phenyl hydroxy malonic ester. In a typical synthesis 7.5 g. of sodium was dissolved in 100 ml. of absolute alcohol. To this sodium alcoholate was added 25 g. of phenyl hydroxy malonic ester and 14 g. of aniline. The mixture was heated to 115-120° and stirred for about 16 hours. The excess alcohol was evaporated, reducing the pressure with a water pump. To the dried solid remaining was added ice and water, and dilute hydrochloric acid was added with stirring until the mixture was faintly acid to litmus. The semi-solid mass remaining was extracted with ether, dried, the ether evaporated, and the

residue crystallized from benzene. The melting point at this stage was 140-145°.

This partially purified product was transferred to a small test tube and heated in a metal bath to 200° for about two hours. It was then crystallized from benzene until its melting point was unchanged at 151°. Yield from 1 to 3 g. of the highly purified product. Analysis: calcd. for

$$C_6H_5—CH(OH)—CONHC_6H_5,$$

C, 74.0; H, 5.7; N, 6.1. Found: C, 74.2; H, 5.9; N, 5.84. A mixed melting point with known anilide of mandelic acid (m.p. 151°) showed no depression.

This compound was further shown to be the anilide of mandelic acid by boiling 0.5 g. of the compound in 20% aqueous potassium hydroxide for four to five hours. The alkaline solution was extracted with ether, dried and the ether evaporated. To the residue was added chloroform and dilute sodium hydroxide and the mixture was then heated. The typical amine odor was produced.

To the potassium hydroxide solution was added excess hydrochloric acid, and this acidified solution was warmed on a steam bath for three to four hours. The acid solution was evaporated to dryness and the residue was extracted with benzene. From this benzene solution a white solid crystallized (m.p. 116-118°). Mixed m.p. mandelic acid (m.p. 120°) was 118-119°. Thus aniline and mandelic acid were produced upon saponification with potassium hydroxide which would be expected from the anilide of mandelic acid.

A similar experiment was carried out using p-toluidine instead of aniline and the yield was 2 g. of

$$C_6H_5—CH(OH)—CONHC_6H_4—CH_3—p$$

(m.p. 171°). o-Toluidine failed to produce any comparable product. Presumably steric hindrance would explain this difference. m-Toluidine gave results comparable to p-toluidine.

Use of magnesium methylate-magnesium ethylate mixture as condensing agent. Eight grams of magnesium turnings was added to 100 ml. of absolute methyl alcohol. After the magnesium had all reacted, 150 ml. of ethyl alcohol, 12.5 g. of phenyl hydroxy malonic ester and 7 g. of aniline were added and the mixture stirred at 115-120° for about 16 hours. From here on the procedure was the same as when sodium ethylate was used. Yield 1.5 g. of the anilide of mandelic acid, which indicates that magnesium is about as effective as sodium in this reaction.

Reaction of phenyl hydroxy malonic ester and aniline without any condensing agent. Ten grams of phenyl hydroxy malonic ester and 15 g. of aniline were heated eight hours at 200° in a test tube. The mixture was cooled and crystallized from benzene (m.p. 150°). Mixed m.p. with the anilide of mandelic acid showed no depression. Yield 1.2 g.

The authors wish to express their indebtedness to Dean William M. Blanchard, who was instrumental in securing a research grant from the Indiana Academy of Science to promote our research program.

Summary

1. An attempt was made to synthesize N-aryl-2,4-diketo-3-hydroxy-3-arylazetidines using the procedure previously used to make 2,4-diketoazetidines. In each case amido derivatives of mandelic acid were formed.

2. It has been demonstrated that the same derivatives of mandelic acid can be made by heating directly phenyl hydroxy malonic ester and the aromatic amines.

Studies on Lithium Acetylide

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The University of Notre Dame

In contrast to the large amount of work done on the acetylene derivatives of sodium, potassium and calcium, little attention has been paid to the analogous compounds of lithium. In 1898 Moissan[1] prepared lithium acetylide on a small scale, by the action of acetylene on a liquid ammonia solution of lithium. He reported that lithium acetylide was less soluble in liquid ammonia than sodium acetylide, and that when isolated from the solvent, it was less stable, undergoing decomposition with evolution of acetylene. On the basis of the weight of lithium acetylide obtained from a given weight of lithium, and from the amount of acetylene liberated on hydrolysis, he assigned to lithium acetylide the formula $C_2Li_2.C_2H_2.2NH_3$. Since that time no references to lithium acetylide or lithium alkylacetylides have appeared in the literature. It was the purpose of the present work, therefore, to prepare and analyze lithium acetylide and a lithium alkylacetylide, and to compare their reactions with those of the better known sodium derivatives.

Experimental Procedure

Preparation of Lithium and Sodium Acetylides.—Acetylene gas, washed by bubbling through concentrated sulfuric acid, was passed into two liters of liquid ammonia, while 7 g. (1 mole) of metallic lithium, cut in small pieces, was added gradually, with stirring, at a rate such that the solution did not develop a permanent deep blue color. When the solution became colorless after the addition of the last piece of lithium, the flow of acetylene was stopped. Sodium acetylide was made in the same way from 23 g. of sodium. The alkali acetylides so prepared were used immediately, without isolation.

Reaction of Sodium and Lithium Acetylides with n-Amyl Bromide.—One mole of n-amyl bromide (151 g.) was added during half an hour, to a freshly prepared solution of lithium acetylide made from 7 g. of lithium. The reaction mixture was stirred for 2.5 hours, and was then hydrolyzed by the addition of ammonium hydroxide and water. The organic layer was washed with water, dilute hydrochloric acid, and 10 per cent sodium carbonate solution, and was dried over magnesium sulfate. The product was then fractionated through a Vigreux column. The reaction of sodium acetylide with n-amyl bromide was carried out in exactly the same way, using the same number of moles of reactants. Duplicate runs were made with each acetylide.

Reaction of Sodium and Lithium Acetylides with Methyl Ethyl Ketone.—Lithium and sodium acetylides were prepared as described

[1] Moissan, 1898. Compt. rend., 127:911.

above, and 73 g. (1 mole) of methyl ethyl ketone was added to each solution, with stirring, over a period of forty minutes. The reaction mixtures were stirred for three hours, and the liquid ammonia was allowed to evaporate through a potassium hydroxide tower. The residue in each case was hydrolyzed at 0° with ice and 50 per cent sulfuric acid, the organic layer was washed with brine, dried over magnesium sulfate and distilled through a Vigreux column. Duplicate runs were made.

Analyses on Lithium Acetylide.—Lithium acetylide for analysis was made from 1 g. of lithium, 300 cc. of liquid ammonia and carefully-dried acetylene. Care was taken to exclude moisture during the preparation, and when the reaction was complete, the liquid ammonia was allowed to evaporate through a potassium hydroxide tower. The alkalimetry determinations were made by adding 10 ml. of dioxane to a weighed sample, to prevent explosion, and then adding 70 ml. of water. The base liberated was titrated to the methyl-orange end point with 0.4 N. hydrochloric acid. In the determinations of lithium as lithium sulfate a sample of the acetylide was gently heated in a porcelain crucible, with a direct flame, until decomposition was complete. The residue was moistened with concentrated sulfuric acid and the crucible was finally heated to dull redness. The alkalimetry and lithium determinations were carried out on four successive days to follow the decomposition of the substance. Since lithium acetylide gradually decomposes on standing, with liberation of acetylene, it cannot be stored in a closed weighing bottle. It was kept in an open flask, protected from moisture by a potassium hydroxide tower.

Thermal decomposition of lithium acetylide.—Weighed samples were heated in a current of nitrogen, and the emerging gases were passed through standard sulfuric acid to absorb ammonia and then through silver nitrate solution to absorb acetylene. The excess sulfuric acid in the first wash-bottle was determined by titration to the methyl-red endpoint, and the nitric acid liberated in the silver nitrate solution was also determined by titration. The weight of the residue was obtained, and the residue was then decomposed with dioxane and water, and the alkalinity of the solution determined by titration.

Solubilities of lithium and sodium acetylides.—Liquid ammonia was allowed to evaporate from a solution of the alkali acetylide until the acetylide began to precipitate, and the volume of the solution was noted. Liquid ammonia was then added until solution was again complete, and the volume again noted.

TABLE I.—Yields of Products from Lithium and Sodium Acetylides

Product	B.pt.	Per Cent Yield from Lithium Acetylide	Per Cent Yield from Sodium Acetylide
n-Amylacetylene	97-100°	67.5	65
Methylethylethinylcarbinol	61°/70 mm.	59	65

Lithium n-amylacetylide.—One-half mole of lithium (3.5 g.), cut in small pieces, was added gradually to 500 ml. of liquid ammonia containing a small amount of ferric nitrate. To the lithium amide solution so prepared 55.8 g. of n-amylacetylene was added gradually. The lithium n-amylacetylide was then treated, without isolation, with 0.5 moles of n-amyl bromide, added over a period of forty minutes. The reaction mixture was stirred for thirty minutes, and then hydrolyzed with ammonium hydroxide and water. The organic layer was washed, dried, and distilled in the usual way, and gave a 60 per cent yield of di-n-amylacetylene.

The liquid ammonia was allowed to exaporate (through a drying tower) from one portion of lithium n-amylacetylide, and weighed samples of the residue were decomposed with dioxane and water, and the base formed determined by titration.

Discussion of Results

The results obtained in this work indicate that lithium acetylide is stable in liquid ammonia solution, and probably has the formula $LiC\equiv CH$, since it reacts normally with alkyl halides and ketones to give the expected products.

$$LiC\equiv CH + C_5H_{11}Br \longrightarrow LiBr + C_5H_{11}C\equiv CH$$

$$LiC\equiv CH + CH_3CO{-}C_2H_5 \xrightarrow{H_2O} C_2H_5C(CH_3)(OH){-}C\equiv CH$$

From the data in Table I it will be seen that these products are obtained from lithium acetylide in substantially the same yields as they are from sodium acetylide. No evidence was obtained for the presence in the products of any di-amylacetylene or dimethyl-diethyl-butynediol, which would be formed if any appreciable amounts of lithium carbide, Li_2C_2, were present in the liquid ammonia solution.

In contrast to the report of Moissan, we found that lithium acetylide is more soluble in liquid ammonia than is sodium acetylide, since 1 liter of liquid ammonia was required to dissolve one mole of lithium acetylide, whereas 1300 cc. were required for one mole of the sodium salt.

Lithium acetylide appears to undergo spontaneous decomposition with liberation of acetylene, during its isolation from liquid ammonia, since the substance immediately after isolation contains 32% of lithium, whereas lithium acetylide, LiC_2H, should contain but 21.7% of lithium. There is probably no appreciable ammonia of solvation, since the amount of base formed on hydrolysis can be substantially accounted for by the amount of lithium present. The analytical results are summarized in Table II.

TABLE II.—Analyses on Lithium Acetylide

Time After Isolation	Equiv. of[a] Base per g.	Equiv. of[b] LiOH per g.	Per Cent of Li.
One day	.....	0.0463	32.4
Two days	0.0445	0.0428	30.0
Three days	0.0448	0.0428	29.95
Four days	0.0449	0.0407	28.5
Calc'd. for LiC_2H:	....	0.0312	21.7
Calc'd. for $Li_2C_2.C_2H_2.2NH_3$:	.....	0.0408	14.2
Calc'd. for Li_2C_2:	.....	0.0527	36.6
Calc'd. for $Li_2C_2.LiC_2H$:	....	0.0428	29.8

(a). Total basicity as determined by titration.
(b). Equivalents of LiOH per g. as calculated from the per cent of Li found.

These results show definitely that Moissan's formula for lithium acetylide is erroneous, but they do not permit us to postulate a definite formula for lithium acetylide. On the basis of the evidence presented, the most plausible explanation is that lithium acetylide decomposes to an approximately equimolar mixture of lithium acetylide and lithium carbide, and that there is some ammonia vapor occluded, in the first few days, at least. As this gradually diffuses out, and is replaced by air, partial oxidation occurs, with consequent decrease in the per cent of lithium. Calcium and barium acetylides have been shown to undergo similar decomposition to complexes of the carbides.

When lithium acetylide was heated at 150° in an atmosphere of nitrogen for thirty minutes a small amount of ammonia was evolved, and a still smaller amount of acetylene, and the residue increased in lithium percentage. When the substance was heated at 100° for two and a half hours, only a trace of acetylene was liberated, together with a little ammonia. These results indicate that ammonia of occlusion is driven off fairly easily, but that the approximately equimolar mixture of lithium acetylide and lithium carbide does not readily liberate much acetylene to form a mixture richer in the carbide.

In contrast to lithium acetylide, lithium n-amylacetylide is stable both in liquid ammonia solution and when isolated. In liquid ammonia solution it reacts normally with amyl bromide to give the expected di-n-amylacetylene. Analysis of the isolated salt by titration showed it to contain 6.35% of lithium, whereas the percentage of lithium in a compound of the formula $LiC{\equiv}C{-}C_5H_{11}$ is 6.8%

The authors wish to express their appreciation to Mr. Charles J. O'Boyle and Mr. John T. Doyle, who carried out part of the experimental work reported in this paper.

Summary

1. Lithium acetylide has been prepared in liquid ammonia solution, and shown to react normally with alkyl halides and ketones.

2. Lithium acetylide decomposes on isolation from liquid ammonia. Analyses show that the formula $Li_2C_2.C_2H_2.2NH_3$, suggested by Moissan, is erroneous, and that probably the substance when isolated from liquid

ammonia decomposes to an approximately equimolar mixture of lithium acetylide and lithium carbide.

3. Lithium n-amylacetylide has been prepared and shown to react normally with alkyl halides. It is stable when isolated from liquid ammonia solution.

Some Recent Trends in the Chemistry of the Carbohydrates

ED. F. DEGERING, C. A. BURKHARD, and A. A. DIETZ, Purdue University

It has been calculated by the National Farm Chemurgic Council that something over 84,000,000 tons of by-products of agriculture are being wasted annually. This list includes wheat straw, corn stover, cotton stems and pods, oat hulls, and corn cobs. "Research is plugging away," according to Gustavus J. Esselen, "at this problem, patiently, persistently. . . . Hulls and pods and straw and stems—who knows what the magic of chemistry may eventually work with these waste products?"

The magic of chemistry has already been at work in this field. From burrs, cobs, hulls, stalks, and straw, a vast array of products have already been produced and some of these have found their way into commercial production. Substitute woods, "which range from those as hard as stone to others as soft as cork bark, some denser than the heaviest teak wood and others lighter and stronger than balsa wood," have been fabricated from waste agricultural products.

Wood has been subjected to hydrogenolysis to give water-white liquids which can be fractionated without decomposition to yield important raw materials for further synthesis. This may be one of the answers to the replacement of our petroleum supply, which, according to the organic theory, came originally from carbohydrate material. The other alternative is to apply adequate heat and pressure to carbohydrate material to convert it into petroleum-like products. An energetic worker in the carbohydrate field recently wrote: "It is very interesting that plants and animals are able to make almost anything from the sugars. . . . It is about time for us to be able to do more of these things in the laboratory." The chemist out-did nature in the synthesis of indigo, yet there are innumerable analogous opportunities in the field of carbohydrate chemistry.

The production of lumber utilizes only about 20% of the forests whereas the new technic for the disintegration of wood to fibers and the subsequent recombination of these under heat and pressure to give pressed board, makes use of about 93% of the forest crop. This represents a saving of 73% and tremendously simplifies the important problem of reforestration.

Etholcel, which is probably obtained by treatment of sodium cellulose with ethyl chloride, was developed in 1936 and is now being marketed by the Dow Chemical Company as a competitive material for cellulose acetate, cellulose nitrate, and similar products.

Director Stine, of du Pont, is responsible for the statement that "there are ten thousand different products of cellulose being produced and the industry is still in its infancy".

Starch acetates are now available on pilot plant scale in three types: (1) those soluble in water, (2) those soluble in both water and organic solvents, and (3) those that are soluble only in certain organic solvents.

These appear to be of interest as chemicals for sizing, for flotation, for films, and allied uses. The lower starch ethers have been prepared in the laboratory, but enough is not known at this time of their properties to predict their use if any in our industrial program.

Among the newer food products are Dri-Dex, Fro-Dex, Liquid Sugar, Malto-Dextrine, and Sweetose. The Dri-Dex, Fro-Dex, and Malto-Dextrine are all produced by the vacuum pan drying of appropriate corn syrups. Liquid sugar is produced by an acid hydrolysis of starch in the presence of molybdenum salts, whereas Sweetose is produced by a combined enzymeacid hydrolysis of starch.

Levulinic or 4-ketopentanoic acid is obtained from waste sugars and starch by a special type of reductive hydrolysis.

Starch is being depolymerized by either (a) the wet process or (b) the dry process. In the wet process the nature of the end product is determined by the type of starch, the hydrogen ion concentration, and the time of heating, whereas in the dry process there are two additional variables: the moisture content of the starch and the temperature of the reaction. By proper control of all of these variables, it appears possible to produce a starch product for a large variety of needs.

Among the newer uses for starch should be mentioned that of torrefying the starch in situ in the fabrication of corrugated cardboard. In 1939, according to Dr. G. E. Hilbert, this accounted for the consumption of 80,000,000 pounds of starch. Another rapidly expanding outlet for starch is the sizing of painted walls, which may be washed in turn and resized as needed by the use of a dilute starch solution. It is reputedly reported, furthermore, that definite progress has been made in the design and construction of an engine which operates on pulverized starch.

The discovery, by Denny and co-workers at the Boyce Thompson Institute, of a rather large number of chemicals that will stimulate budding and root growth has received a large amount of publicity, but it is not generally known that these workers have been able to show that when ethylene chlorohydrin is used as such a stimulate it is detoxicated by the plant by glycoside formation. In the study of potato tubers and gladiolus corms it was observed that gentiobiose, not normally present or at most in a minimum concentration, is produced to detoxicate the ethylene chlorohydrin by the formation of the corresponding gentiobioside. These workers have, moreover, found that it is possible to dormatize tubers by treatment with either a dilute solution of potassium naphthaleneacetate or the vapors of methyl naphthaleneacetate. These dormatized tubers may be dedormitized at will by treatment with ethylene chlorhydrin or other stimulating chemicals. This work is of paramount importance, if it can be adequately controlled, in that it will enable storage without danger of germination.

Three new approaches are now available for continued study of the size and structure of the starch molecule. By the preparation of the thioacetal, which takes place only at the free aldehyde group, it is possible to estimate by mercury or sulfur determination, the terminal aldehyde groups at any given time in the hydrolysis. Similiar measurements seem possible by use of the dropping mercury cathode and by the

use of complete alkylation, followed by high vacuum fractionation of the alkylated residues. As a result of these studies it appears that some of the starch molecules may be very highly branched.

The various sugars can now be separated analytically by complete methylation of the mixture, followed by fractional distillation and identification of the various fractions. The technic has been extended to the analysis of the ingredients of dextrins and corn syrups.

A synthesis of some interest to the vitamin chemists is that of ascorbic acid or vitamin C from D$^-$-threose and ethyl bioxylate in the presence of mild alkali as a condensing agent. The first step in the reaction appears to be addition, which is followed by the loss of water and ethyl alcohol.

The hydrogenolysis of D+-glucose is being thoroughly investigated in the quest of a new source for the polyalcohols and other synthetic intermediates.

The technic for the production of lactic acid, from either milk or starch, has been improved and a high grade is now available for either the food or the synthetic-products industries. The various esters of lactic acid as well as their derivaties, the acrylic esters, are being used in increasing amounts in the lacquer and allied trades.

The condensation of the simple sugars with phenolic compounds to give complex cyclic structures, by Niederl and collaborators, may suggest how nature synthesizes some of its complex colored substances.

Aside from the items indicated here, mention should be made of the twenty-seven pages devoted to the Chemistry of the Carbohydrates and Glycosides in the Annual Review of Biochemistry, Vol. IX, 1940.

The magic of chemistry is at work and the diligence of the research worker in the field of carbohydrate chemistry is being awarded by these mile posts of progress.

GEOLOGY AND GEOGRAPHY

Chairman: W. D. THORNBURY, Indiana University

Robert Karpinski, Indiana State Teachers College, was elected chairman of the section for 1941.

ABSTRACTS

Some observations on the relation of the geography of Indiana to its geological history. J. E. SWITZER, Indiana University.—The geologic history of Indiana is responsible to a great extent for its economic and industrial development. Southwestern Indiana's coal deposits are largely due to the accumulation of vegetative material in inland swamps during the Pennsylvanian period. Geologic conditions permitted the formation of supplies of natural gas and oil. In the Mississippian period the clear waters of an inland sea made possible the deposits of pure limestone from Bloomington to Salem. Due to the glacial period we have the rich level plains of more than two-thirds of our state. To it also are due the gravel deposits, the many lakes, and marshes, some of which have been drained and furnish valuable farm land. The Great Lakes, also due to the Ice Age, determined that great transportation lines should cross our state. The topography, which was due to geologic and physiographic forces, determined the routes by which settlers should enter in the state's early history, thus controlling somewhat the type of people composing its population.

Silurian correlations in the East Central Province. E. R. CUMINGS, Indiana University.—Silurian correlations in Ontario and the Great Lakes states have been vitiated heretofore by the traditional scheme of correlating all the great dolomite formations of this region as Lockport. Thus such formations as the Byron of Wisconsin and Michigan (even the Mayville of these states), the Laurel and Louisville of Indiana, etc., have been correlated with the Lockport. Even the Waldron shale has been so correlated, though its fauna is typical Rochester in character, and it was correlated with the Rochester (Niagara shale) by James Hall. The Mississinnewa shale of northern Indiana is clearly Rochester and not Lockport. More and more of these dolomites and associated beds have in recent years, by the writer, Foerste, and others, been transferred to the Clinton, or at least to a position below the Lockport. It is now definitely proven that the Engadine (Racine) formation of Ontario and Michigan is the true Lockport of the Great Lakes region, and that all beds below it are therefore pre-Lockport. The Manistique coral beds were by Foerste regarded as Clinton. They may occupy the hiatus between the Rochester and the Lockport. With these may be correlated the Louisville formation and the upper Liston Creek formation of Indiana. This makes the Laurel and Waldron definitely pre-Lockport. In this category will also be placed the Joliet and "Waukesha" of Illinois and the lower cherty Hopkinton of Iowa. In Ohio everything below the Cedarville-Springfield

(Durbin) is pre-Lockport. The typical Guelph with *Megalomus*, of northwestern Ohio, probably represents the "upper Huntington" (above the New Corydon) of the Fort Wayne wells; and the New Corydon may correlate with the Eramosa dolomite of Ontario. The Huntington of the Indiana outcrop area is Racine.

Electricity generation in London, England. CHAUNCY D. HARRIS, Indiana University.—During the World War the London area was supplied with 72 different types of electrical current from 65 generating stations operated by 59 distributors and 8 railways. Supply areas were small, because they had been established before electricity could be transmitted more than a few miles. The Central Electricity Board was formed in 1926 to coordinate the generation and distribution of electricity. It replaced the diffuse pattern of small stations located within independent distribution compartments with a linear pattern of stations along waterways. These stations produce for a coordinated interconnected system. Twenty-four small stations have been closed and four new stations have been opened. These four new stations located on the River Thames generated 64% of the electricity for the London area in 1937. Five factors have been used by the Board in its selection of stations to be continued and of sites for new stations: (1) The cost of coal delivered to the station; Thames-side stations have an advantage of about 75 cents per ton. (2) Availability of water for condensing purposes; only the Thames furnishes adequate water for large stations, if cooling towers are to be avoided. (3) Efficiency of the station. (4) Proximity to the load. (5) Possibilities of the site for further expansion. The new organization of coordinated generation, interconnection, and uniform supply has resulted in significant capital economies, operating economies, and strategic advantages.

An unusual case of unified cavern drainage. CLYDE A. MALOTT, Indiana University.—Sloans Valley in southern Pulaski County, Kentucky (Burnside Quadrangle), is a karst valley near the dissected western margin of the Cumberland Plateau, consisting of approximately 9.8 square miles of drainage area. It is adjacent to the deeply intrenched valley of the Cumberland River into which the drainage of the karst valley is discharged through a cavern route. The surface drainage system was formerly a well balanced dendritic system descending from the sandstone ridges into a trunk valley a little more than three miles in length. The floor of this former trunk valley is developed in the Mississippian limestones at approximately 800 feet in altitude and about 150 feet above the present Cumberland River. Only a short stretch of the trunk valley at its upper end is used by the present surface drainage, as underground drainage has been developed both in the perched trunk valley and in its tributary branches. The side branches are dismembered distals, each having its terminus in a swallow-hole. At least 11 accessible openings leading into caverns are present in this well developed karst valley, among them being the Cumberland caverns adjacent to U. S. Highway 27, which crosses the valley.

During the past summer (1940) the caverns were mapped in detail. About 30,000 feet of the cavern routes were mapped within the underground system. It has been definitely ascertained that the caverns mapped comprise a unified underground drainage system. The main route of the storm water course of the invading surface waters is about 3.5 miles in length, fully three miles of which have been mapped in detail. Drainage from 4.3 square miles of the upper part of the surface system, known as Martins Creek, enters swallow-holes in the creek bed or flow directly into Martins cavern. Martins cavern has been mapped for about 2,000 feet. A stretch of approximately 2,200 feet remains unmapped between it and Minton cavern into which the waters enter. The course of the waters in Minton cavern has been mapped for a distance of 5,800 feet. Approximately 1.8 square miles of other drainage from the valley enter Minton cavern. An unmapped break of 350 feet intervenes between Minton cavern and the pieced together Cumberland caverns through which the storm waters pass for a distance of 7,800 feet en route to Cumberland River. The Cumberland caverns receive an additional surface drainage from about 2.3 square miles. Thus, 8.4 square miles of the drainage of Sloans Valley debouch into Cumberland River at the terminus of the cavern system. Only 1.4 square miles of the valley drainage goes through independent cavernous routes to the Cumberland River.

This unified trunk route of an underground system is believed to be the longest most completely mapped underground drainage course in the country. Its bearing on the manner of cavern development is of special importance, as the cavern features and the relations of the older and younger parts of the system clearly reveal the importance of the developmental work of the invading surface waters.

The chorographic bulletin board: a geographic device for evaluating event-environment relationships. ALFRED H. MEYER, Valparaiso University.—Modern geography has come to be known as the "relationship" science, showing the interrelationships existing between the facts of the cultural world and the facts of the physical world. Current events lend themselves excellently to chorographic treatment.

To aid the geography student in this task, particularly in the analysis of present-day world problems, a specially constructed "chorographic bulletin board" is suggested. This "board" supplies an inventory of all the commonly recognized physical and cultural forms of the landscape. All the landscape features, over 500, are classified under conventional headings, and to each is affixed a numbered tack. Pertinent maps and other illustrative material accompany the outline.

A chorographic treatment of a news item determines first of all which of the numbered tack features constitute the basic correlation criteria. Next, rubber bands, representing bonds of geographic relationships, are stretched from such tacks from sides of the board to the center, to link together, as it were, the geographically interrelated stage and story elements.

Cold Winters in Indiana. A. V. LOTT, Sellersburg.—Winter temperatures in Indiana are determined primarily by the major movements of the secondary circulation. Indiana's position, relative to the positions of the permanent pressure areas of the world, is such that the atmospheric drift over the state is usually controlled by the circulation around the permanent pressure areas of the North Atlantic. The slow oscillation of these pressure areas seems to follow a fairly regular cycle and one or more cold winters occur at the critical stage of each half-cycle. The sequence seems to be as follows: mild dry winters, cold winters, mild moist winters, cold winters, mild dry winters, etc. Since each type of winter occurs at a particular stage in the cycle it is suggested that its occurence may be predicted with a fair degree of accuracy.

Petroleum Production in Indiana

WALLACE T. BUCKLEY, Indiana University

Indiana is at present experiencing its second major oil boom. The first, reaching its peak in 1904, occurred in the Trenton Field of northeastern Indiana. The present boom, which began in 1937, is generally confined to southwestern Indiana, the eastern portion of the Illinois Coal Basin. The increase in activity in Indiana's petroleum fields promises to more than triple the state's oil output for 1940 over that of 1936.

The search for petroleum is not a new venture in southwestern Indiana. This district was the scene of the state's first oil discovery which occurred about 1865 when developments in Pennsylvania stimulated prospecting throughout northeastern United States. Production of petroleum in commercial quantities, however, did not occur until 1888 when a pool was discovered in the vicinity of Terre Haute. The productivity of this pool resulted in an intensive search for oil but no further important discoveries were made until 1903 when the Princeton Pool in Gibson County was developed.

During this period the probable output of the fields of southwestern Indiana did not exceed 10,000 barrels annually and the district was completely overshadowed by the Trenton Field. Northeastern Indiana's Trenton Field produced about 150,000 barrels in 1890. Five years later the annual production was 4,500,000 barrels. The upward trend in Trenton output continued until 1904 when the peak production of 11,339,000 was reached. Its decline was as precipitous as its rise and six years after the peak, production had fallen to about 1,000,000 barrels annually. In 1930, northeastern Indiana production amounted to less than 100,000 barrels annually.

During this period of rapid decline in the Trenton Field, the fields of southwestern Indiana were increasing in importance and by 1910 their production about equaled that of the Trenton Field. The discovery of the Oakland City Pool in Pike County in 1907, the Edwards Field in 1911 and others, mainly in Sullivan, Daviess, Gibson and Pike counties, brought southwestern Indiana's production from about 10,000 barrels annually to 800,000 barrels annually, near which level the output held until the present boom got under way. It is estimated that for the past twenty-five years about 90 per cent of Indiana's total production has been from the southwestern fields.

During the period between 1905 and 1910 in which oil production in southwestern Indiana increased from a few thousand barrels annually to approximately 800,000 barrels annually, a parallel development was taking place across the Wabash River in southern Illinois. From practically nothing in 1905, Illinois oil production soared to over 30,000,000 in 1908, 1909, 1910 and 1911. The decline of the Illinois fields was gradual and by 1930 had fallen to the 5,000,000-barrel level where it remained until 1937. Since 1937, new discoveries in Illinois have resulted

in a spectacular increase in oil production in that state. 92,000,000 barrels of petroleum were produced in 1939 and production for the first six months of 1940 indicates that the yield for this year will approach 150,000,000 barrels. This production places Illinois in fourth position in the United States, outranked only by Texas, California, and Oklahoma.

The discovery of new and spectacular oil producing horizons in Illinois had a stimulating effect on the oil industry of southwestern Indiana. The first effect on Indiana was the beginning of a "lease play" which started in the latter months of 1937. Leasing activity reached its maximum intensity in 1938 and by January, 1939, it is estimated that 90 per cent of the southwestern counties of Indiana were under lease. Another estimate places the leased acreage at between 3,000,000 and 5,000,000 acres, for which the landowners had received more than $1,000,000. Independent producers and speculators as well as many of the major oil companies were engaged in this leasing activity. By July, 1939, 1,147,000 acres were held by twenty of the major producing companies, five of which held more than 100,000 acres each. The maximum holding for any one company was 460,000 acres.

During the early stages of leasing in 1937 the prices paid for oil leases seldom exceeded 10 cents per acre with 25 cents per acre annual delay rentals. As competition increased, prices increased to $1.00 per acre with $1.00 per acre annual delay rentals. By the end of 1938 as much as $25.00 per acre was required to secure unproven acreage in favored districts. After the discovery of the Griffin Pool, prices rose as high as $100.00 per acre in that district. Over the region as a whole, however, exploratory work in the first years of the boom was not overly encouraging and prices remained generally less than $1.00 per acre.

The first year and one-half of the present oil boom was featured largely by leasing activity and exploratory work. Not until the early months of 1939 did the number of well completions show a noticeable increase (Figure 1). In 1937, oil wells completed numbered thirty-nine, and dry holes numbered fifty. In 1938, the oil wells completed were forty-four in number and the dry holes fifty-four. These figures compare favorably with those for 1935 and 1936, years prior to the boom, when the oil well completions were forty-eight and forty-five, respectively.

An interesting part of the exploratory work carried on in the first two years of the present boom was the use of geophysical methods. The seismograph was used by most of the large operating companies. In general the most intensive surveys were made in the extreme southwest or deeper part of the Illinois Basin. One company, however, worked on the outer rim of the Basin in Martin, Lawrence and Orange counties. By the middle of 1939, exploratory work utilizing the seismograph was largely completed. Gravimiter crews, employed by two of the major producers, worked the entire Basin rather thoroughly. Core drilling also played an important part in the exploratory work.

The entire economic life of southwestern Indiana has been quickened by the tide of men and money associated directly or indirectly with the the oil boom. The picture, however, is not without its darker side. Many of the smaller communities have found their municipal organizations

inadequate to cope with the increased population and related problems. Particularly serious are the matters of housing, water supply, sanitation and school facilities. These towns and villages, realizing the nature of the oil industry, hesitate to make permanent improvements to meet demands that may prove to be transitory.

Following the initial leasing and exploratory phases of the oil boom came the increase in the number of wells being drilled in southwestern Indiana (Figure 1). The results of this drilling activity became apparent in April and May, 1939, when the number of completions rose sharply. Oil wells completed in 1938 numbered 44; in 1939, 170; and in the first eight months of 1940, 163 oil wells were completed. Figure 2 shows the location of the oil wells and dry holes completed in southwestern Indiana for the three-year period ending October, 1940.

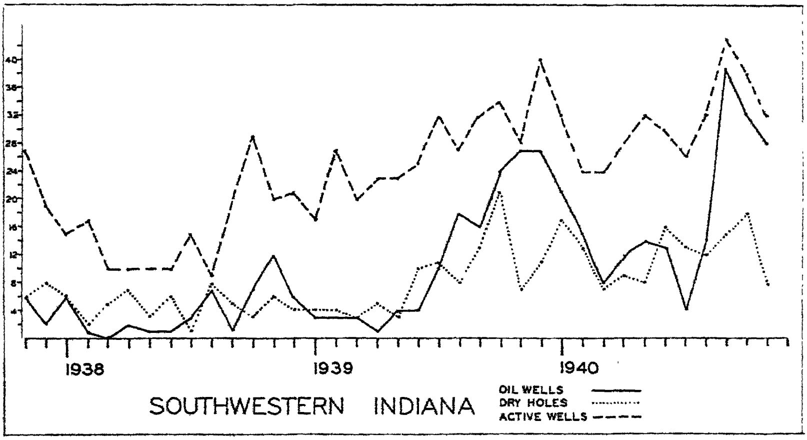

Fig. 1. Oil wells and dry holes completed and wells actively drilling in southwestern Indiana, for the three year period ending October, 1940.

The most important discovery up to the present time is the Griffin Pool, located in the southwest corner of Gibson County. The discovery well was brought in in December, 1938, with a production of 604 barrels of oil per day. Although flood waters of the Wabash retarded work in the spring of 1939, eight months after the completion of the discovery well there were thirty-seven producing wells in the field.

On October 1, 1940, 179 wells with an average daily production of seventy-six barrels each were producing about 13,000 barrels of oil per day. In the light of present information as to the proven area and the nature of the producing horizons, it has been estimated that the probable reserves of the pool amount to some 13,000,000 barrels, or a producing life of more than thirty years at the present rate of recovery. Extension of the proven area and discovery of deeper producing horizons are possibilities that may increase greatly the importance of the Griffin Pool.

The Heusler Field, in southeastern Posey County, was brought into production in June, 1938. The discovery well was rated as pumping

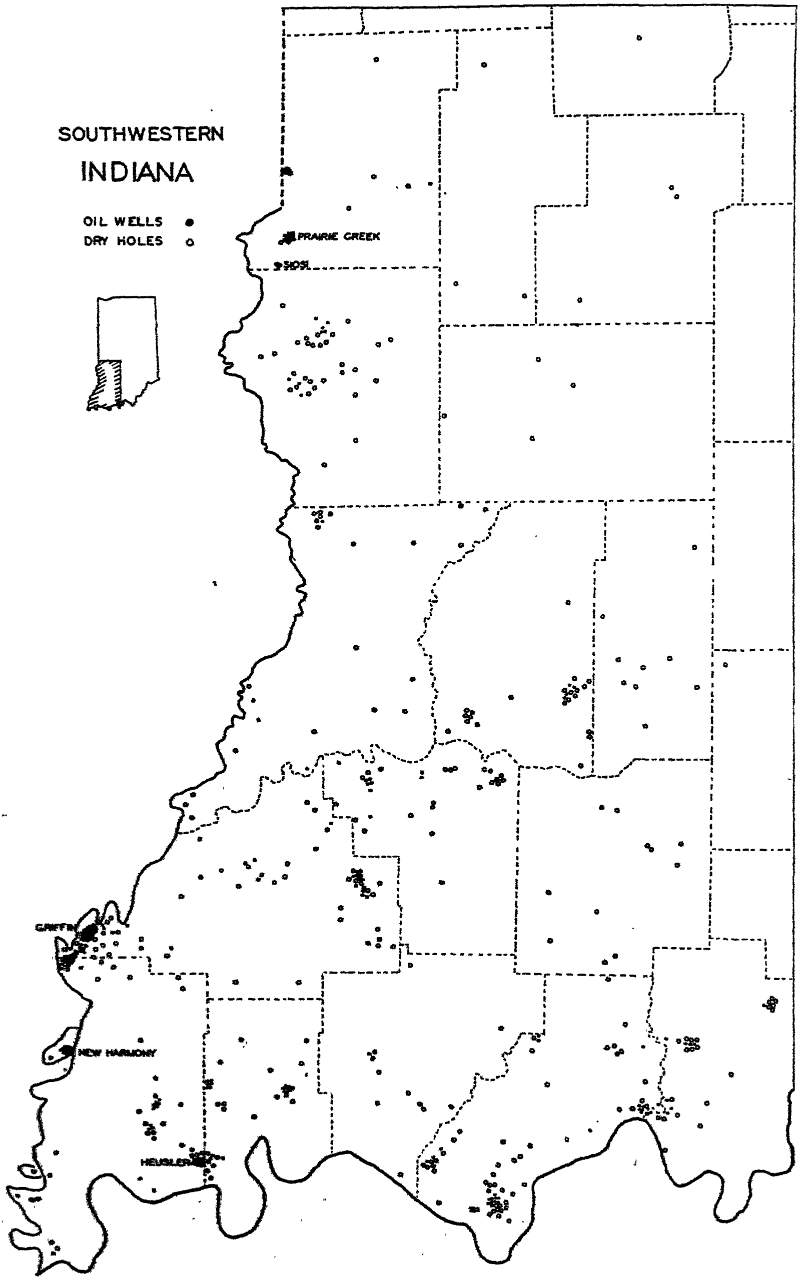

Fig. 2. Location of oil wells and dry holes completed in southwestern Indiana in the three year period ending October, 1940.

twenty-three barrels of oil per day. At present there are thirty wells with an average daily production totaling 600 barrels.

The discovery well of the New Harmony Field, southwest of the town of New Harmony in Posey County, was completed in June, 1939, with an average daily production of 252 barrels of oil daily. This is one of the fields that was located by seismic exploration. The field is completely owned by one company and has been systematically developed on a ten acres spacing plan. The estimated area of the field is 250 acres and by the end of August, 1940, twenty-four wells had been drilled. The average daily output of these wells totals 2,161 barrels and at this rate of production the field has an estimated productive life of about six years.

Other important developments have taken place in the Siosi and Prairie Creek fields of Vigo County. The five fields, Griffin, Heusler, New Harmony, Siosi and Prairie Creek, produced in August, 1940, from 386 wells, a total of about 16,000 barrels of oil per day. In the same month the 1,010 wells in the so-called old fields in southwestern Indiana produced 1,100 barrels of oil per day. Production for the state has increased steadily from 822,000 barrels in 1936 to 1,436,000 barrels in 1939, and 1,725,000 barrels for the first six months of 1940.

To date the state of Indiana has made no provision to insure maximum recovery of its newly found petroleum resources or maximum life for this rejuvenated industry. Orderly development is taking place in at least two of the new fields by virtue of the fact that they are completely owned by single companies. In general, the petroleum industry in Indiana is wide open and the stage set for a repetition of the boom and disaster type of exploitation which occurred in the Trenton Field thirty-five years ago.

Your Knowledge Against Professional Opinions

CLARENCE L. BROWN, Northwestern University

Geographers are frequently confronted with the problem of the choice of texts and supplementary teaching materials which are best suited to specific courses. There are many standards which may be used in measuring the quality of such materials. One of these standards is the determination of materials used professionally. This paper presents a summary of a survey which was not planned to produce exhaustive and final results but rather to show highly selective and directional results.

With an anticipated increase in the number of teachers securing master's degrees, the question was raised concerning the adequacy of departmental reference libraries in specific materials. These materials relate to a one-semester college course in the Geography of North America. This course was emphasized because of its importance in the high school curriculum. In order to have a means of comparison, it was decided to make a survey of the specific professional materials recommended by a highly select group of nationally recognized institutions.

"The institutions included in this survey are all members of the Association of American Universities, which is recognized as one of the leading accrediting agencies in the country. This association, consisting of thirty-two universities, is deeply concerned with raising the standards of work in colleges and universities. It was therefore assumed that responses to this survey from these institutions would give a picture of practices in superior institutions."[1] Thus, with the establishment of a sound principle and practice it was decided to enlarge the survey for the professional benefit of the teachers and students, by including typical, specific geography courses in the junior and senior high schools. The survey was interested in securing judgments and recommendations as to textbooks, atlases, wall maps, and collateral readings of these three levels of maturation. The questionnaire was sent to those institutions of the Association of American Universities which offered courses in geography. Of the twenty-three universities to which the questionnaire was sent, returns were received from fourteen.

I. Junior High School Material Recommended.

Textbooks: Whitbeck, Whitaker, and Durand, *The Working World* (2).*

Atlases and Maps: Goode, *School Atlas* (7).

[1] Brink, W. G., Professor of Education, Assistant Dean Graduate School, Northwestern University.

* Refers to the number of times the material was recommended. Hence, the numerical values may serve as indices. No attempt has been made to arrange these materials in any form of classification other than by giving numerical value.

Collateral Readings: *Journal of Geography* (1). *Geographic News Bulletin* (1). Huntington, *Principles of Economic Geography* (1). Salisbury, Barrows, and Tower, *Elements of Geography* (1).

II. Senior High School Material Recommended.

Textbooks: Colby and Foster, *Economic Geography* (6). Smith, J. R. *North America* (2). Smith, *Men and Resources* (2). Ridgley and Ekblaw, *Influence of Geography on Our Economic Life* (2). Jones, C. F., *Economic Geography* (2).

Atlases and Maps: Goode, *School Atlas* (9). Philip and Finch, *Standard School Atlas* (2). Philip, *Senior School Atlas* (2). Philip, *New Handy General Atlas* (2).

Collateral Readings: Jones, C. F., *Economic Geography* (3). Colby and Foster, *Economic Geography* (2). Ridgley and Ekblaw, *Influence of Geography on Our Economic Life* (2). Case and Bergsmark, *Modern World Geography* (2). Smith, J. R., *Men and Resources* (2). *Journal of Geography* (2).

III. Recommended Material for a One-Semester, Regional College Course in the Geography of North America.

Textbooks: Smith, J. R., *North America* (9). Atwood, *Physiographic Provinces of North America* (1). Smith, J. R., *Men and Resources* (1). Miller and Parkins, *Geography of North America* (1).

Atlases and Maps: Goode, *School Atlas* (10). Lobeck, *Physiographic Diagram of the United States* (4). Atwood, *Regional Map of North America* (3). Denoyer-Geppert, *Economic Maps* (2). Philip, *Senior School Atlas* (2). Philip, *New Handy General Atlas* (2). *Geological Maps* (2).

Collateral Readings: English and American Periodical Literature (9). *Geographical Review* (4). Fenneman, *Physiography of the Eastern United States* (3). Fenneman, *Physiography of the Western United States* (3). Miller and Parkins, *Geography of North America* (2). Parkins and Whitaker, *Our National Resources and their Conservation* (2). Parkins, *The South* (2). Bennett, *Soil Conservation* (2). Foreign and United States Government Reports (5). *Economic Geography* (3). Statistical Abstracts of the United States (3).

Taking the survey as a whole, it is interesting to observe that of the thirty-two institutions which make up the Association of American Universities, twenty-three offered courses in geography. Of these twenty-three institutions covered by the questionnaire, fourteen responded. In these fourteen institutions the paucity of knowledge relating to the teaching materials and techniques of the junior and senior high schools was astonishing and seems rather disheartening.

Some Observations of the Glacial Drifts North of the Driftless Area in Wisconsin

FRANCIS DOAN HOLE, Earlham College

North Central Wisconsin is a gently rolling plain which slopes south and is somewhat dissected in the vicinities of the Wisconsin and Black Rivers. Outcrops are of pre-Cambrian crystallines in the northern portion, and of Cambrian sandstones, siltstones and clays in the southern portion. Except for an east-west strip about ten miles wide on the south, these rocks are covered with a mantle of glacial drift which averages about ten feet in thickness. The northern part of the area is crossed by a strip, five miles wide, of rugged hills which consist of glacial deposits, and which constitutes the "Terminal Moraine" of the Cary substage of the Wisconsin drift.

Glacial geologists have found it difficult to determine the age of the "border drift" which lies south of the terminal moraine and north of the Driftless Area. Previous work in this and adjacent regions has been done by Samuel Weidman (1), Frank Leverett (2), F. T. Thwaites (3), John Mathiesen (4), and Lewis Nelson (5.) Weidman distinguished, largely on the basis of topography, three border drifts, the southernmost of which he considered the oldest, and all of which he thought to be older than the terminal moraine and the drift north of it. They were, in order: "First Drift," almost wholly on sandstone, and extremely dissected; "Second Drift," thicker but devoid of kettles, although bordered by a moraine between Marshfield and Neillsville; "Third Drift," which was like the Second Drift, but showing a few kettles and knolls, mainly gravel. Leverett concluded that the extra-morainic drift is chiefly Illinoian, although he recognized some extensions of Wisconsin drift south of the terminal moraine. His field maps are on file in the office of the Wisconsin Geological Survey at Madison. In a letter to F. T. Thwaites, he suggested that there may be only one border drift, and that soil profiles are probably the most reliable criterion. Thwaites and Mathiesen suggested that there are two border drifts in adjacent Northwestern Wisconsin, the younger of which, lying farthest north, is probably Iowan, judging from the pitted outwash which characterizes it. Nelson is the only one of the investigators named above who has depended on other criteria besides the criterion of topography. He concluded that the Marathon silt loam in North Central Wisconsin developed from the Colby silt loam which occurs on all the border drifts distinguished by Weidman, and which also occurs north of the terminal moraine.

The writer made observations, summarized below, of soil profiles in this area in July and August, 1940. Alteration of drift, sources of drift, and stratigraphy of drift are the objects of the present study.

Observations

1. Calcareous drift was found in this border drift and in the terminal moraine, which were hitherto believed to be noncalcareous. A strip of drift which is calcareous at from three to fourteen feet lies on both the First and Second Drifts of Weidman in the vicinities of Auburndale and Marshfield. The conclusion suggested is that the calcareous drift cannot be older than Iowan.

2. The reddish brown color of the drift near Marshfield has been considered proof of the great age of the drift. Reddish brown and bluish grey clays and silts were observed interbedded with crossbedded sandstone, and several cuts in drift showed reddish brown and bluish grey tills irregularly interpenetrating. North of Marshfield, reddish brown till was found near valleys, while dull brown till lay on the uplands. The conclusions suggested are as follows: the red color of some of this drift is inherited from materials, while in other places it has been brought about under conditions of good drainage. Drift of the terminal moraine is probably red because Lake Superior basin clays and silts were red. The excessive stoniness of that till may indicate a separate readvance of the ice which moved about due south.

3. Of the four soil series significant in this study, the Colby and the Marathon which developed from it are the most important. The A and B_1 horizons of the Colby soil have been observed on calcareous drift, on noncalcareous drift, on columnar reddish brown clay loam of the B_2 horizon, on non-columnar sandy loam, on residual granite "gravel", and on reddish brown drift north of the terminal moraine. The conclusion suggested is that the drift north and south of the terminal moraine is apparently all young.

4. At the State Agricultural Experiment Station at Marshfield, there is a black soil buried about fifteen feet beneath calcareous drift. The conclusion suggested is that a series of older till, sand, gravel, and clay underlies the calcareous drift.

5. One observation indicates that the disintegration of the granite in the vicinity of the Wisconsin River valley has taken place since the till was deposited although considerable alteration had doubtless occurred before.

Mechanical and chemical analyses in the laboratory, and further field investigation are necessary to throw light on many problems. Is the erosional topography due primarily to bed rock control? Has a glacial readvance brought northern drift to overlie calcareous drift from another direction? Can columnar structure develop in the B_2 horizon of a soil as young as the above suggested conclusions make the Colby silt loam? Is the light brown soil on the quartzite Rib Mountain (relief, 800 feet) loess or weathered till?

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Indiana Regional Contrasts in Large Corn Yields

STEPHEN S. VISHER, Indiana University

In the *Proceedings* for 1938, the regional contrasts in average corn yields were mapped and discussed, as were the county average yields in the best one-fifth of the years and in the best year of the fifteen studied. The maps were made from estimates compiled by the Crop Reporting Service of the U. S. Department of Agriculture (1). The present study is of yields of 100, 125, 140, 150 and more bushels per acre authenticated by the Indiana Corn Growers Association. This study has three chief objectives: 1) To make more widely known Indiana's unexcelled record in the production of large yields and to present some of the reasons for this high rank. 2) To throw light upon the comparative significance of various factors which affect yields. This is aided by revealing the significant regional contrast in the frequency of big yields. 3) To illuminate the problem of weather and crop yields (2). This is aided by disclosing the fluctuations from year to year in the number and size of yields.

The first of the accompanying maps shows the distribution by counties of the 3,605 five-acre tracts which have produced some time in the fifteen years 1923-1939 an authenticated yield of one hundred or more bushels of corn per acre. The figure entered in each county is the total number of such yields in that county. The counties which are most darkly shaded have had the most such yields, each of them at least sixty-five during the fifteen years. The counties which are unshaded have had fewer than fifteen such yields, several of them none.

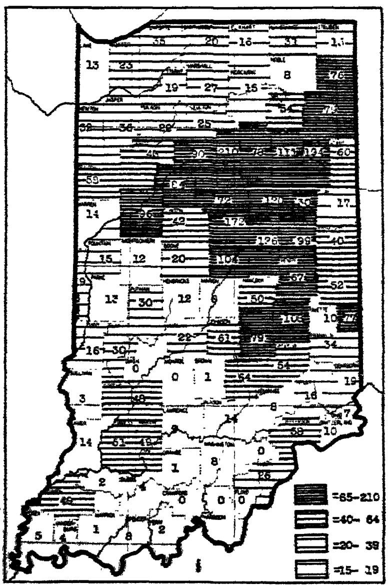
An authenticated yield of one hundred bushels per acre or more for the average of a five-acre plot entitles the member producing it to a gold medal awarded by the Indiana Corn Growers Association, which Association includes the outstanding corn growers of Indiana. The data for Figures 1 and 2 were obtained from the Annual Reports of the Association (3).

The first map makes conspicuous the fact that the farmers of a triangular region extending from Union County at the southeast and DeKalb County at the northeast to Lafayette at the west have grown an exceptional number of hundred bushels per acre yields. To almost all of the counties in that region have gone at least sixty gold medals during the fifteen years.

Few of the farmers of southern Indiana have succeeded in obtaining hundred bushel corn yields. In six counties none have been authenticated during these fifteen years; three others have had only one such yield and several others have had only a few.

The northern-most counties of Indiana have had many more big yields than have most of those of southern Indiana, but Figure 1 shows clearly that the counties along the northern border of Indiana have fewer than those not quite so far north.

A more surprising revelation of this map is that the western counties of Indiana have had far fewer high yields than have the eastern counties. This is despite the fact that corn is of especial importance in most western counties and also that Purdue University is located in the western part of the State. Purdue University, through its experiment station, agronomy department, and extension division, has played an important role in helping the more progressive farmers to obtain high yields.



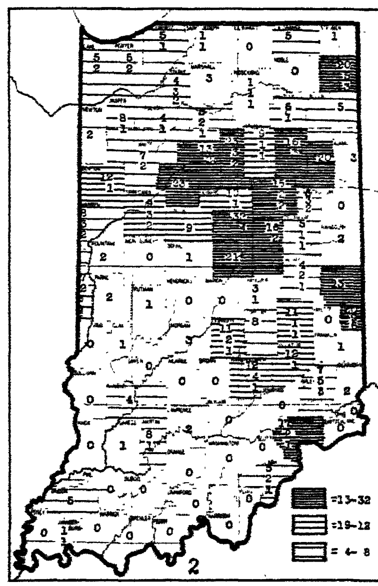


Fig. 1. Number of hundred-bushel corn yields, 1925-1939. Data from Annual Reports, Indiana Corn Growers Association.

Fig. 2. Number of corn yields of more than 125 bushels, 1925-1939. First figure is total, second is 140-bushel yields, third is 150-bushel yields. Data from Annual Reports, Indiana Corn Growers Association.

No county bordering Illinois is in the highest classification on this map and only two are in the second classification. On the other hand, three of the eastern-most counties are in the highest category and three others are in the second.

The fact that the most southern and the most northern counties have had relatively few hundred-bushel yields is by no means entirely due to the inferiority of the soil. The five-acre tracts which have had hundred-bushel yields are practically all carefully fertilized, and although the average soil is not so good in some counties as in others, at least small areas of soil adapted to successful fertilization occur in each county. The highest yield ever obtained in Indiana was produced on well-fertilized muck land in northern Indiana and the second highest yield was produced on river-bottom land in southern Indiana.

Hundred-bushel corn yields, nearly three times the normal or average Indiana yield, are obtained only when several conditions are favorable. Superior seed is required, of course, as well as highly fertile soil, excellent care and proper spacing of the plants. These conditions practically always are achieved as a result of exceptional knowledge and effective work on the part of the farmer. But even though the farmer does his work with the best of skill, a big yield is not possible unless the weather is favorable. The importance of the weather is shown by the variation from year to year in the number of hundred-bushel yields obtained by the same farmers. For example, in 1925 there were 191 such yields in Indiana, but the next year there were only about a fifth as many (forty-one). In 1929 there were 105 such yields but in 1930, when most of the state was affected by a severe drouth and exceptionally high temperatures during July, there were only twenty-three yields of a hundred bushels per acre or more. These were mostly in localities which happened to have thunder storms which broke the drouth. Likewise, during 1934, when a mid-summer drouth was widespread, there were only thirty-four farmers who had hundred-bushel yields. In 1935, there were more than three times as many (113). In 1936, likewise, there was a severe drouth with record-breaking high temperatures, with the result that only seventy farmers succeeded in getting hundred-bushel yields. In 1937, weather conditions were exceptionally favorable and 596 hundred-bushel yields were authenticated. The weather was good in 1938 and 686 hundred-bushel yields were authenticated; in 1939 weather conditions were remarkably favorable during the weeks which are most important for corn, with a partial result that 1,499 Indiana farmers harvested yields which averaged for five acres an authenticated one hundred bushels per acre or more. The number of authenticated hundred-bushel yields in the other years of this fifteen-year period is as follows: 1927 (65), 1928 (40), 1931 (37), 1932 (93). For convenience of comparison with these high yields, the Indiana average corn yields for 1925 to 1939 were as follows: 1925 (43.5), 1926 (38), 1927 (31.3), 1928 (35.2), 1929 (32), 1930 (26.5), 1931 (39), 1932 (37.5), 1933 (29.5) 1934 (24.8), 1935 (38), 1936 (25.5), 1937 (45), 1938 (41), 1939 (51.5).

The larger number of big yields during the last few years compared with most of the early ones is partly due to the widespread recent use of hybrid corn, which was almost unknown a few years ago. Nevertheless, many of the big yields of recent years and even of 1939 were not of hybrid corn. Factors of great importance, however, in explaining the increase in high yields are the increased knowledge of the agricultural methods by which such yields can be obtained when the weather is favorable, and the desire to compensate for the reduction in acreage called for by the Soil Conservation Act. This Act, by encouraging the growing of legumes, has also been significant in improving the soil.

The influence of outstanding leadership is shown on this map at numerous points. Counties which have had, at least for a time, agricultural agents possessed of special ability and enthusiasm stand conspicuously ahead of their neighbors. Examples are Martin, Daviess, Gibson, and Jefferson counties. The exceptionally high standing of

Tippecanoe County, because of the accessibility of Purdue University, is another example of the clear influence of leadership. On the other hand, certain counties have done much less well than the records of their neighbors suggest is possible. The farmers of such counties presumably have not had as successful leadership in this respect, or else some other conditions have been unfavorable.

When the number of high yields is totalled by groups of counties, most of the irregularity which is due to the presence of a few exceptional farmers disappears. For example, despite the good record of a small group of farmers in Martin County, the south-central fifteen counties of Indiana have had an average of less than a single hundred-bushel yield per county per year. By contrast, an equal number of counties of the same average size in the eastern part of north-central Indiana, Grant County and its neighbors, have had a county average of about ten such yields each year. Likewise the sixteen most northerly counties have each produced an average of only one or at the most two such yields per average year while each of the sixteen counties just to the south of these northern ones produced an average of about two and one-half times as many. Just south of the best part of the state in this respect the average number of high yields is even smaller than it is in the most northernly sixteen counties, and the average decline continues and increases fairly rapidly toward the south. The eight counties bordering on the Ohio River west of Louisville have produced a total of only twenty such yields in the fifteen years despite the famous fertility of the river-bottoms. The ten counties bordering Illinois produced 223 such yields, or an average of 1.4 per year each, while the ten counties bordering the state of Ohio produced more than twice that many (459).

Another way of stating the regional contrasts in big yields is: Of the counties which have few or no hundred-bushel yields, only two are in the northern third of the state, seven are in the central third and twenty-one are in the southern third, including all but one of those which have not had such a yield in this fifteen-year period.

Thus it is apparent that with two chief exceptions there is an average increase both toward the north and toward the east in the number of high yields. The first of these exceptions is that the most northernly counties do less well than do those not quite so far north. The second exception is that southwestern Indiana stands almost as high as southeastern so far as number of yields per county is concerned, although not in the size of the yields. (Several of the highest yields produced in Indiana came from the southeast, none of them from the southwest.) Part of any advantage which the southwest has over the southeast in the number of high yields per county is, however, due to the fact that the counties of southeastern Indiana are relatively small in area.

Some comparisons between Figure 1 and some maps published in the Indiana Academy of Science Proceedings for 1938 (1) are of interest. The area of most hundred-bushel yields is not the one in which corn occupies an exceptionally large percentage of the crop land. That area is mostly in the south-central part of the state, where, for example, in Pike and Brown counties fifty-seven and fifty-six per cent of the crop

land, on the average, is in corn. This means that much corn is planted year after year on the same land.

Many of the counties with numerous hundred-bushel yields are in the area which had, during the fifteen years studied, relatively high average yields; thirty-eight to forty-three bushels per acre for the entire county. The part of the state which has low average yields (less than twenty-nine bushels per acre), include only two of the counties shaded in the present maps, namely, Jefferson and Clark.

The part of the state which has county average yields of from forty to forty-eight bushels in the best one-fifth of the years includes all the counties with the most hundred-bushel yields with the exception of Tippecanoe County. None of the counties which have county average yields of less than thirty bushels per acre in the best one-fifth of the years are shaded on the present map. However, only three of them (Crawford, Perry and Owen) have not received at least one authenticated hundred-bushel yield. Only the far northern counties and Fayette County have relatively high county average yields in their best one-fifth of the years and yet have relatively few hundred-bushel yields. (Fayette County is relatively small in area.)

One hundred-twenty-five-bushel Yields

Figure 2 shows the distribution of the 517 yields of 125 bushels per acre or more which have been authenticated by the Indiana Corn Growers Association during 1925-1939. Even in Indiana, yields of 125 bushels per acre are less than one-sixth as numerous as yields of 100 to 124 bushels. Indeed they were quite rare until 1939 when 274 farmers were fortunate enough to obtain so large a yield. The other years of these fifteen had the following number of 125-bushel yields: 1937 (92), 1938 (84), 1925 (12), 1927 and 1932 (each 9), 1933 (7), 1931 (6), 1929 and 1934 (each 5), 1935 and 1936 (each 4), 1928 (3), 1926 (2), 1930 (1).

On Figure 2 some of the counties have more than one typed figure. The second, if it is present, indicates the number of authenticated yields of 140 or more bushels per acre which have been received in these fifteen years. The third figure, for the few counties possessing it, records the number of yields of 150 bushels or more per acre.

This second map is shaded with respect to the number of 125-bushel-per-acre yields. The counties which have had most such outstanding yields are shaded most. The medium shading indicates from nine to fourteen such yields, and the lightest shading indicates three or less. Twenty-eight of Indiana's ninety-two counties have not had during the fifteen years an authenticated 125-bushel yield.

The counties which have grown the largest number of 125-bushel yields of corn are nearly all situated in north-central Indiana, but several southeastern counties also stand high. No county on the northern border of the state has had more than five such yields in these fifteen years and of those which border on the Ohio River only one has had more than five, namely Jefferson County. Of those bordering on Illinois, three counties about mid-way between north and south have had seven to twelve such yields. Three of the counties on the eastern margin of the

state have had from thirteen to twenty such big yields. Of the counties which have not recorded a 125-bushel yield, three are in the northern third of Indiana, seven in the central third and nineteen in the southern third.

The two western tiers of counties have had seventy-nine yields of 125 bushels or more, the two central tiers have had 158, the two eastern ones, 161.

It appears, therefore, that until the northern and the eastern borders of the state are approached, there is a general northward and eastward increase in the 125-bushel yields comparable to that noted in the hundred-bushel yields.

One-hundred-forty-bushel Yields

Yields of 140 bushels per acre are decidedly more rare than those of 125 bushels. During 1925-1939, inclusive, there have been only eighty-seven such big yields, of which fifty-two occurred in 1939. The number in the other years were: 1937 (15), 1938 (10), 1931 and 1932 (each 2), and one each in 1925, 1927, 1933, 1934, 1935 and 1936. There were none in 1930.

The number of the 140-bushel yields which have been authenticated in each of the counties is indicated, it will be recalled, by the second figure in the county on Figure 2. Thirty-three of Indiana's counties have recently had this large yield. The counties with the largest number of such yields are: Union, nine; DeKalb and Ripley, each five; Tipton, four; Blackford, Huntington, Miami, Starke, Tippecanoe, and Warren, each three; Cass, Clark, Fulton, Grant, Henry, Jefferson, Johnson, Lake, Madison, Porter and White, each two; and the following, one each: Delaware, Hancock, Howard, Jasper, Kosciusko, LaPorte, Pulaski, Rush, St. Joseph, Vanderburgh, and Whitley.

The distribution of the yields of 140 bushels or more per acre is not so sharply concentrated as is that of the yields of 100 to 139 bushels per acre. Such exceptional yields reflect the skill of the grower even more than they do favorable natural conditions. Most of them have been produced by men who repeatedly have had yields large enough to win gold medals from the Indiana Corn Growers Association. Just the right amount of the proper fertilizer, just the right spacing of the corn, neither too little nor too much cultivation, and, of course, highly productive seed are required as well as favorable weather. To add to the difficulties is the fact that the spacing which is best in a wet season is not the same as that in a dry one. Similar variation occurs in cultivation and fertilization.

These high yields (140 bushels), however, have not been obtained in two-thirds of the state's counties, including those in the western half of the state south of the Wabash River, with the one exception of Vanderburgh County. Moreover, that exception had a yield only slightly over 140. This strongly suggests that the prolonged hot weather of southwestern Indiana interferes seriously with high yields. The considerable number of high yields in northern counties suggests that, whenever the season of warm weather is sufficiently long and moist, high yields can

be obtained with proper fertilization and other care. The nine high yields in Union County are of interest, not only because of the active friendly rivalry between several outstanding corn growers, but because Union County is relatively elevated (the county averages 960 ft.), and hence has lower average temperatures than its latitude implies. (The average elevation of southwestern and south-central Indiana is less than 500 ft.) Union County is appreciably cooler than most of the other southern counties (4).

Corn Yields of One Hundred-fifty Bushels or More Per Acre

During 1925-1939 there have been in Indiana thirty-four authenticated yields of 150 bushels or more of corn per acre. Of these, twenty-one were received in 1939, seven in 1937, two in 1932 and one each in 1927, 1931, 1934, and 1938.

There have been during the fifteen years studied eleven authenticated yields of 160 bushels or more per acre of corn in Indiana, seven of them in 1939, two in 1937, and one each in 1932 and 1934. Of these eleven, five have been of more than 170 bushels per acre, two each in 1937 and 1939 and one in 1934. Two yields of more than 180 bushels per acre have been received, one in 1934 and the other in 1939.

The state record for Indiana is 182.6 bushels per acre, produced in 1934 by Harold Pankop, of Corunna, DeKalb County. The second highest yield is of 180.1 bushels per acre, produced in 1939 by Clark Dellinger, of Jeffersonville, Clark County, on the Ohio River. Neither of these record yields was of hybrid corn; the larger was of Reid Yellow and the second was of Johnson County White. The third largest yield, of 179.1 bushels per acre, was produced in 1937 by R. L. Heilman, of Hope, Bartholomew County. This production and the next and many following were with hybrid corn. The fourth highest yield was of 178 bushels per acre grown in 1939 by Paul McCray, of Liberty, Union County. The fifth was of 173.6 bushels grown in 1937 by Alvin C. Brown, of Holton, Ripley County (Johnson County White Corn). Louis Whipple, of College Corner, Union County, holds sixth place with 169.8 bushels of hybrid corn produced in 1939. Other high records in decreasing order are as follows: 7) 167.8 bushels in 1939, Nelson Jones, Whiteland, Johnson County; 8) 165.6 bushels by Herman Pankop, of Corunna, DeKalb County, in 1932; 9) 162.5 bushels by Ewart Farrar, Walkerton, Starke County, in 1939; 10) 162.3 bushels by A. Clamme, Hartford City, Blackford County, in 1939; 11) 162.0 bushels by Alvin C. Brown, of Holton, Ripley County, in 1939.

Most of the foregoing holders of 160-bushel records have in other years produced from 140 to 160 bushels per acre, because, as already remarked, these high yields require exceptional agricultural skill as well as favorable weather. Acquiring this exceptional skill usually takes years. Many of the most successful corn growers began by producing 75 to 85 bushel yields (for which they received a bronze medal from the Indiana Corn Growers Association), then they won a silver medal by obtaining a 85 to 99 bushel yield. Subsequently they produced more than a hundred-bushel-per-acre yield. Some of them won several gold medals

with progressively higher yields whenever weather conditions were favorable. The first authenticated Indiana yield of over 130 bushels per acre was obtained in 1925 (144 bushels), the first yield of over 150 bushels was obtained in 1927 (152.6); the next one of over 140 bushels was obtained in 1931 (156). The next year, the latter farmer set a new record of 165.6 busels, and three years later his younger brother set the present record of 182.6.

Indiana Compared With Other States

Extended correspondence has disclosed that several states have corn growers' associations modelled after Indiana's. They have, however, operated for fewer years, and use somewhat different standards. For example, the unit of area considered is ten acres in Ohio, Illinois, and Iowa, instead of five, as in Indiana and Minnesota. It is believed, however, by men qualified to judge the matter, that more than ninety per cent of Indiana's hundred-bushel yields have come from fields of ten acres or more. Only in the muck lands of northern Indiana and in some of the river bottoms of southern Indiana are five-acre fields important in the contests. In parts of these latter areas it is impossible to have compact ten-acre fields of high fertility.

A significant variation in standards used is with respect to moisture content. New corn varies widely in moisture content from season to season and field to field, occasionally having as much as thirty-five per cent of its weight moisture; rarely as little as ten per cent. The standard used in Indiana is 17.5 per cent; in Ohio it is 20 per cent; in Illinois 16.5; in Iowa 15.5; and in Minnesota 14. The authenticated yields reported from each state are based on the adopted moisture content. Consequently, interstate comparisons require recalculation of the yields to put them on a comparable basis.

Ohio produced in twelve years (1917-1928) 181 hundred-bushel yields, while Indiana produced 571 in the same period. The highest authenticated yield was 176.2 bushels per acre, which on the basis of the moisture content used in Indiana would be slightly less than 172 bushels. Indiana has had five authenticated yields in excess of 172 bushels.

Illinois in ten years (1930-1939) had 187 hundred-bushel yields, of which 102 were in 1939. (The comparable totals for Indiana were 3,220 and 1,499). During 1939 three Illinois farmers obtained 150-bushel yields, in contrast with twenty-three in Indiana. The highest Illinois yield ever authenticated was 155.4 bushels in 1939. This is equivalent to 157 bushels with 17.5 per cent moisture. A map of Illinois' hundred-bushel yields reveals that only two were produced in the southern thirty-five counties; by contrast, the thirty-five counties of northern Illinois had 117 such yields or nearly two-thirds of the state's total as well as the largest yield. The northern-most tier of counties had, however, only one such yield, and only two counties of the eastern tier had a 100-bushel yield. The largest number of high yields have been obtained from the central and north-central part of the state.

Iowa, during 1938 and 1939, had 328 100-bushel yields; 265 in 1939, in contrast with 2,185 for Indiana. The highest yield authenticated for

Iowa is 163 bushels of 15.5 per cent moisture content corn, which is equivalent to 166.5 bushels on Indiana's basis. Indiana had in 1938 and 1939 five larger yields.

Minnesota had in 1939 thirteen hundred-bushel yields on the basis of 17.5 moisture content, the highest being 131. Nine of these yields came from the southern tier of counties, two from the next tier and the remaining two from elsewhere in the southern third of the state.

Scattered reports of larger yields from other states are worthy of mention. Apparently all of them ignored moisture content, and some of them were by measure rather than by weight. (Two bushel baskets of new ear corn often yield less than a bushel of shelled corn of standard moisture content). The highest reported yield, 225 bushels from a single acre in the elevated cooler part of western North Carolina, experts believe, was equivalent to considerably less than 200 bushels of 17.5 per cent moisture corn, a total which has been excelled by the best acre of several Indiana fields. Indeed, one four-acre DeKalb County tract was estimated by competent judges to have yielded an average of more than 200 bushels per acre.

Summary and Conclusions

During the fifteen years 1925-1939, inclusive, authenticated yields of at least one hundred bushels per acre as the average of a compact five-acre tract have been produced on 3,605 Indiana farms, with the result that the farmers have been awarded a gold medal by the Indiana Corn Growers Association. During these years there were 517 such five-acre tracts which produced at least 125 bushels per acre, and eighty-seven which produced at least 140 bushels. Eleven have produced 160 bushels or more, five have produced more than 170 bushels, and two 182.6 and 180.1 bushels per acre.

Although the human factor is of supreme importance in obtaining such phenomenally large yields, favorable weather is essential, as is proved by the wide variation from year to year in the number of big yields. For example, in 1925 there were 191 hundred-bushel yields but in 1926 only forty-one; in 1929 there were 105, but in 1930 only twenty-three. The distribution of these big yields over the state strongly suggests that there is an average improvement in climate for corn from the south northward, until the northern-most counties are almost reached, and from the west eastward, except for the most elevated northeastern counties which have produced fewer large yields than their neighbors. Corresponding northward and eastward average increases were found as to county average yields discussed in the Proceedings for 1938. Northern Indiana normally is distinctly less hot and less subject to July drouth than is southern Indiana and is also less subject to damaging rainstorms (4). The eastern part, because of its greater elevation, also has fewer hours of high temperature than does the western part in corresponding latitudes. Much evidence indicates that for large yields not only must there be abundant rainfall and warmth, but that temperatures above 90° are harmful. (5).

In brief, Indiana farmers have achieved national prominence with respect to both corn yield and corn quality (as shown by many prizes for the finest corn exhibited at the International Livestock and Grain Exposition) not only because many of the farmers are exceptionally well informed and otherwise competent but because Indiana is a superior state for corn growing.

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The Mineral Waters and Health Resorts of Indiana: A Study in Historical Geography

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Introduction

It is the purpose of this paper to describe the growth and decline of the health resorts which made use of the mineral waters in Indiana. Several of these resorts are still in operation. Some have attained national reputation but their status in several instances is rapidly changing. There was a time in the state's history when many more were in existence than at the present. It was thought that a brief review of this once important "industry" might be of interest since its former importance is hardly appreciated by the present generation. This paper may well be called a study in historical geography, for more of the geography involved is of the past than of the present.

Much of the material upon which this paper is based was obtained from various geological reports. Of special value in preparing this paper was Blatchley's[1] report of 1901.

The writer has hunted through the available geological literature for material upon the various parts of the states and, in addition, has during the past summer visited many of the old resort sites and collected from local citizens as much of the history of each as possible. In a few cases exact dates of the operation of resorts were not obtainable, but on the whole the data are rather reliable.

The term mineral water is used in this paper rather loosely, for some of the springs and wells classed as mineral are hardly so in the geological sense of the word. Since they were used for their real or alleged mineral properties no serious error is committed by classing them with the true mineral waters. The term is here applied to all waters developed commercially for their supposed mineral properties.

Early Use of Mineral Waters in Indiana

The use of mineral waters in Indiana antedates the white man, since several of the natural mineral springs of the state were known to and used by the Indians, as well as by the native animals. Numerous salt licks were present in southern Indiana and the buffalo trace which is said to be still discernible in certain parts of southern Indiana was made in part at least by these animals as they sought the salt and minerals from these springs. French Lick owes its name to this fact as does Blue Lick Springs in Clark County.

Among the mineral springs which are said to have been known to and used by the Indians are: the springs at French Lick and West Baden in Orange County; Hazelwood Spring or what was formerly called Elk

[1] Blatchley, W. S., 1901. The Mineral Waters of Indiana. Ann. Rept. Department of Geology and Natural Resources. 26:11-158.

Spring at English, in Crawford County; Indian Springs in Martin County; Blue Lick Springs in Clark County; Ash Iron Springs east of Boonville in Warrick County; and Kickapoo Springs northeast of Attica in Fountain County.

French Lick Springs are probably the oldest known mineral springs in Indiana. The French at Vincennes attempted to establish a salt depot there but it was broken up by the hostile Indians. George Rogers Clark in his Memoirs mentions the springs at French Lick. However, improvements were not made at French Lick until in 1836, when the first hotel was built.

Indian Springs, in Martin County, are said to have been opened as a resort as early as 1814 but such information as is available seems to indicate that no hotel was built there until about 1840; so it appears that French Lick should be given the credit for having the first commercial health resort in Indiana.

Growth of Health Resorts in Indiana

Table I below gives the name, location, date of opening, date of closing, and the geological age of the rocks from which the mineral waters are obtained for 41 localities in Indiana where resorts have been or are operated. Appended to this list are 10 other localities where minor commercial uses of mineral waters were made.

The peak in popularity of the health resort in Indiana was reached during the two decades between 1890-1910. During each of these decades there were in operation in Indiana at least thirty hotels or sanitaria. People came to them by the thousands to drink the water and take the baths. Indiana ranked next to Missouri in the middle west in the number of sanitaria in operation.

During these two decades at many localities promotion schemes were started for the purpose of developing some mineral well or spring which had attained more than local fame. One of the most ambitious of these was the proposed construction of an electric railway from Indianapolis as far south as White Sulphur Well in Crawford County near the Ohio River. Various resorts along this route were to be joined to the main line by spurs. This scheme got as far as having a route surveyed. Another scheme proposed the construction of an electric line west from Louisville, Kentucky via Wyandotte Cave to White Sulphur Well in Crawford County. Neither of these was ever completed. A similar project which was begun was the construction of a spur from the C. M. St. P. Railway line at Cale, in Martin County, to Trinity Springs, by a Mr. Walsh who owned that road. He had torn down the large 360 room hotel which was located at Indian Springs and planned to replace it with a fine structure built of Indiana limestone, but when the water at Indian Springs showed signs of decreasing flow, he changed his plans and decided to build the hotel at Trinity Springs. The grade for the railway was built and some metal laid but the road was never completed. The grade for this proposed road can still be seen. Numerous other examples might be cited but these cases are typical of the enthusiasm which existed at the time regarding the value of mineral wells.

TABLE I

Name	Location	Opened	Closed	Geol. Age of Source Rock
French Lick Springs	French Lick, Orange County	1836	Operating	Mississippian
Indian Springs	Indian Springs, Martin County	1840	1900	Mississippian
Trinity Springs	Trinity Springs, Martin County	1840	1930	Mississippian
West Baden Springs	West Baden Springs, Orange County	1846	Operating	Mississippian
Ash Iron Springs	5 mi. E. of Boonville, Warrick County	1850	1900	Quaternary
Coate's Spring	8 mi. S.W. of Petersburg, Pike County	1867	1915	Pennsylvanian
Samson King Mineral Well	4 mi. W. of Memphis, Clark County	1870	1898	Mississippian
Magnetic Mineral Well	Terre Haute, Vigo County	1875	-	Ordovician
Blair Artesian Well	Michigan City, Porter County	1876	1900	Silurian
Lodi Artesian Well	Silverwood, Fountain County	1880	1885	Silurian
Degonia Springs	Degonia Springs, Warrick County	1880(?)	1933	Quaternary
Hazelwood Sulphur Well	English, Crawford County	1885	1889	Mississippian
White Sulphur Well	English, Crawford County	1886	1913	Mississippian
Martinsville Mineral Wells	Martinsville, Morgan County	1887	Operating	Silurian
Abbott's Magnetic Mineral Well	Ft. Wayne, Allen County	1889	1895(?)	Ordovician
Indiana Mineral Springs (Mudlavia)	Kramer, Warren County	1889	Operating	Quaternary(?)
Spencer Artesian Well	Spencer, Owen County	1890	1897	Silurian
Montezuma Artesian Well	Montezuma, Park County	1890	1900	Silurian
Delphi Artesian Well	Delphi, Carroll County	1893	1898(?)	Ordovician
Spiceland Mineral Springs	Spiceland, Henry County	1893	1913	Quaternary
Columbus Sanitarium Well	Columbus, Bartholomew County	1894	1915(?)	Silurian
Garland Dells Mineral Springs	5 mi. N.W. of Waveland, Montgomery County	1895	Operating but not resort	Pennsylvanian
Gosport Artesian Well	Gosport, Owen County	1895	1901	Silurian
Greenwood Mineral Well	Greenwood, Johnson County	1895	1913	Ordovician
Paoli Sulphur Well	Paoli, Orange County	1896(?)	Still open not resort	Mississippian

Attica Artesian Well	Attica, Fountain County	1898	1911	Devonian or Silurian
Feece's Mineral Well	4 mi. S.E. of Rochester, Fulton County	before 1900	Prior to 1900	Quaternary
LaSalle Mineral Springs	2 mi. N.E. of Trinity Springs, Martin County	before 1900	1915(?)	Mississippian
Sweet Sulphur Springs	Near Velpen, Pike County	before 1900	----	Pennsylvanian
Fairview Mineral Springs	Near Boonville, Warrick County	before 1900	----	Quaternary
Mt. Jackson Sanitarium Well	Indianapolis, Marion County	1900	Operating	Ordovician
Cartersburg Mineral Springs	Cartersburg, Hendricks County	1900	1912	?
Nashville Artesian Well	Nashville, Brown County	1900	----	Devonian or Silurian
Shelbyville Artesian Well	Shelbyville, Shelby County	1901	----	Ordovician
Hunter Mineral Springs	Kramer, Warren County	1905	1911	Quaternary
Wabash Valley Sanitarium Spring	3 mi. N. of Lafayette, Tippecanoe County	1906	Operating	Quaternary
Kneipps Springs	Rome City, Noble County	1906(?)	Operating	Quaternary
McCormick's Creek Sanitarium	2 mi. S.E. of Spencer, Owen County	----	----	Mississippian
Reid's Mineral Spa	Richmond, Wayne County	1905(?)	1916(?)	Quaternary(?)
White Crane Mineral Springs	Dillsboro, Dearborn County	1911	Still open	St. Peter
Milan Mineral Well	Milan, Ripley County	1920	1927	St. Peter

Places with Minor Improvements

Paynes Mineral Springs	Clarke County	Farmhouse with baths
Corydon Sulphur Well	Harrison County	Natatorium
Seymour Artesian Well	Jackson County	Bathhouse
Winona Mineral Springs	Winona, Kosciusko County	Bottling Works
Elliott Springs	5 mi. E. of Shoals, Martin County	Farmhouse with baths
Fritzlar Mineral Well	Evansville	Bathhouse
Exchange Mineral Well	Terre Haute	Bathhouse and swimming pool
Kickapoo Magnetic Springs	3 mi. N.E. of Attica	Farmhouse and bathhouse
Rhodes Mineral Springs	Near West Baden	Bathhouse
Lamden Sulphur Springs	Near West Baden	Farmhouse with baths

Figure 1 shows graphically the history of the growth and decline of health resorts in Indiana for the hundred years from 1840 to 1940.

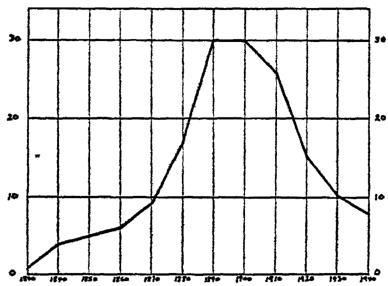

Fig. 1.
Health resorts operating in Indiana by decades from 1840 to 1940.

The data are plotted by decades. It was impossible in several cases to get the exact year in which a resort began operation or closed but it was possible to ascertain this within a year or two of the exact date. Beginning with one resort in 1840 the number increased gradually until about 1875 and then rapidly to its peak during the two decades between 1890 to 1910. During the decade from 1890 to 1899 inclusive there were 30 resorts operating in Indiana. This was true also of the following decade from 1900 to 1909. Beginning about 1915 a rapid decline in numbers set in until in 1940 only eight localities in Indiana had hotels or sanitaria making use of mineral waters.

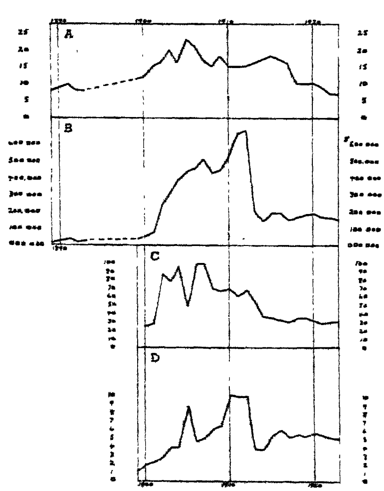

Fig. 2.
(A) Number of commercial mineral wells in Indiana from 1890 to 1923. (B) Value of mineral waters sold in Indiana. (C) Average price per gallon of mineral water sold in Indiana. (D) Millions of gallons of mineral water sold in Indiana.

Figure 1 shows only the number of health resorts operating but Figure 2 gives more details regarding the rise and decline of the mineral water industry. Most of the graphs peak between 1900 and 1915. The graphs which show the values of mineral water sold in Indiana go up rapidly after 1900 due largely to the fact that the large hotels at French Lick and West Baden were built about 1900 and the popularity of their waters for a number of years caused a rapid rise in the value as well as the price received for mineral waters from Indiana.

It is of interest to compare the graphs in Figure 2 with those in Figure 3 which show the history of the mineral water industry in the United States. In general the trends have been much the same, so it appears that the decline which has affected Indiana has been part of a general decline throughout the United States and not a local matter. Data are not available after 1923 on the value of mineral waters produced or the number of commercial mineral springs operating in the United

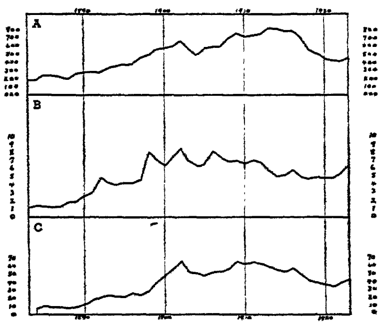

Fig. 3.
(A) Number of commercial mineral springs in the United States. (B) Value of the mineral waters sold in the United States in millions of dollars. (C) Millions of gallons of mineral water sold in the United States.

States. After 1923, the Department of Commerce ceased to publish in the Mineral Yearbook data on mineral waters.

Causes for Decline in Health Resorts

One naturally asks what caused the decline which set in about 1915 in the use of mineral water and health resorts. There were probably several reasons for it. In the first place, the mineral water health resort lost popularity due to the (overly) optimistic claims made for the waters. As a matter of fact at several of the places where sanitaria were built the waters differed in no particular way from ordinary ground water. There is an example of a certain place advertising its waters as "Lithia" waters when analysis showed that there was only one part in a million of lithium in the water. It is true that at most of the localities the waters are strongly mineralized. However, too strong claims were made for many of these waters. It is not uncommon to find them referred to as "having no equal in the state" or in a few instances they were said "to have no equal in the world".

The writer has made a composite list of diseases and disorders which were allegedly cured or benefited by drinking the waters at the various resorts in the state. Following is this list.

Rheumatism, skin disorders, nervous disorders, kidney trouble, gout, neurasthesia, bowel trouble, stomach diseases, dyspepsia, general debility, blood impurities, diabetes, malaria, ague, arthritis, neuritis, neuralgia, lumbago, biliousness, gall bladder trouble, constipation, auto-intoxication, alcoholism, high blood pressure, sleeplessness, hives, eczema, psoriasis, colitis, jaundice, obesity, catarrh, ivy poisoning, ulcers, scrofula, sore eyes, paralysis, and pimples.

If one were to accept seriously the claims made for the mineral waters of Indiana it would seem that there was little left for the doctors to do except to repair broken bones and welcome children into the world. That the use of mineral waters was beneficial in many cases could hardly be denied, but probably the greatest benefit which came from going to one of the health resorts was the rest and relaxation obtained there. Over the baths of Antoninus at Rome, Italy was this inscription:

"Curae vacuus hunc adeas locum
ut morborum vacuus abire queas."

"Come to this place free from care that you may leave it free from disease".

This probably expresses the greatest benefit which the health resort offered to its clientele.

A second factor which contributed to the decline of the health resort was the coming of the automobile. It is no accident that the rapid decline in the popularity of the health resort set in about 1915. Automobiles and good roads were just making their appearance. In its heyday, the health resort served not only as a place for sick people to seek relief from their ills but many of the resorts were favorite vacation spots. American life was much more simple and leisurely in the "Gay 90's" than at present. Today fewer and fewer people are content to spend a week or two in one place. Particularly is this true of younger people. The health resort may still have its attraction to the elderly folks who are looking for a place of quiet and rest but it has largely lost its appeal to the younger folks. The simple recreations which most of them offered, such as billiards, croquet, tennis, and bowling are not sufficient to attract our present generation. Vacations today are frequently spent "on the run" rather than in one place. The automobile and good roads have made this possible.

A third factor which has contributed to the decline of the health resort has been the improvement in the quality of doctors. In the eighties, nineties, and even in the first decade of the present century there were many poorly trained physicians whose prescriptions were in many cases less satisfactory than the treatments received at the sanitaria which in many cases retained competent physicians. Medicine has advanced rapidly in the past two or three decades and greater public faith is placed in the local physician. If he can not help, the invalid is more likely to go to a clinic for examination and diagnosis.

Probably another factor contributing to the decline in the use of mineral waters and to some extent to the health resort has been the improvement in the purity of public water supply. A great deal of the water which was bottled and sold was not strongly mineralized and was used as table water rather than as medicinal water. At a few places water is still bottled for such purposes but in the main the public does not have to buy bottled water in order to feel that its drinking water is pure.

Geographical and Geological Distribution

Figure 4 shows the distribution of slightly over 150 of the mineral wells and springs in Indiana. Some of them are no longer flowing, having been allowed to become clogged with mineral deposit or debris. In general they are much more numerous in the southern part of the state than in the northern part. This is due to a considerable degree to the more favorable topographic and geological conditions in southern Indiana. The southern one-third of the state is either not covered with glacial drift or only thinly veneered with Illinoian drift. The geological formations from which mineral waters are obtained are deeply buried under the Wisconsin drift in most parts of central and northern Indiana and mineral waters are obtained mainly by drilling of wells, except where the glacial drift yields mineral water. In the southern part of the state there are many natural springs in addition to wells.

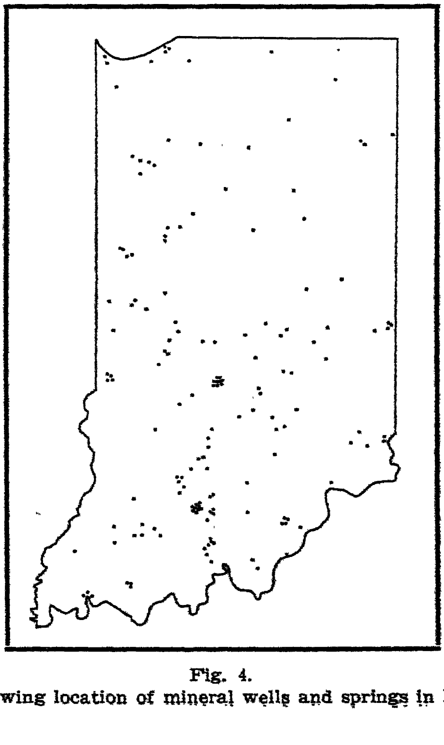

Fig. 4.
Map showing location of mineral wells and springs in Indiana.

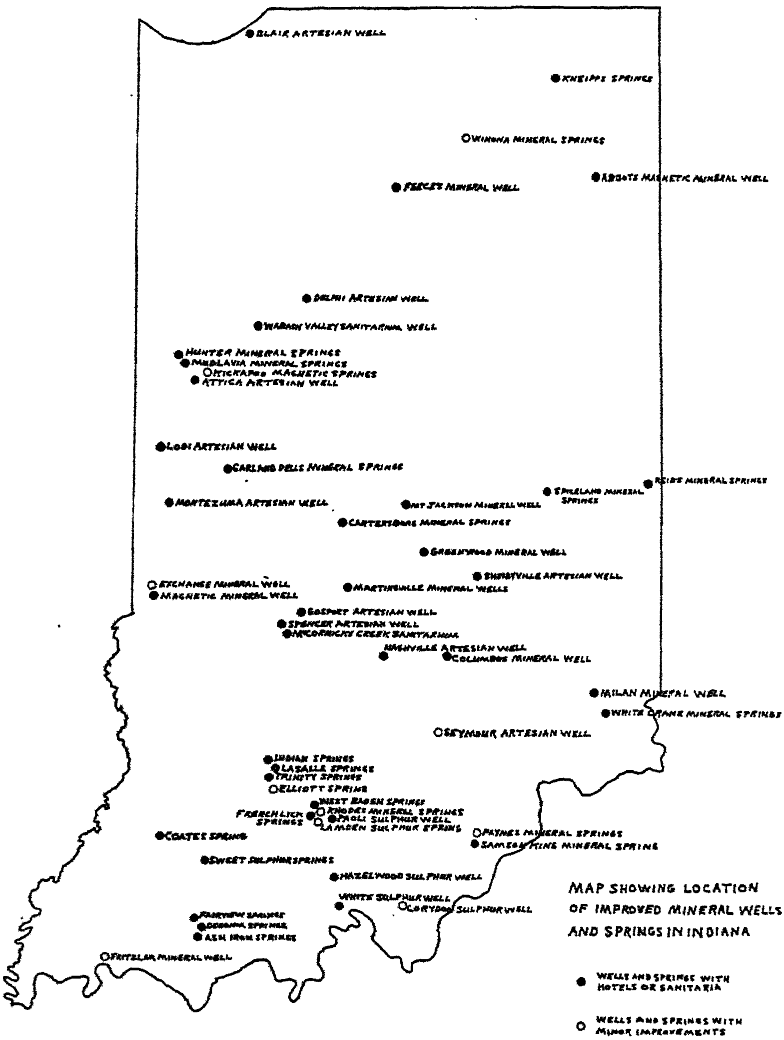
BLAIR ARTESIAN WELL
KNEIPPS SPRINGS
WINONA MINERAL SPRINGS
MINERAL WELL
MAGNETIC MINERAL WELL
DELPHI ARTESIAN WELL
WABASH VALLEY SANITARIUM WELL
HUNTER MINERAL SPRINGS
MUDLAVIA MINERAL SPRINGS
KICKAPOO MAGNETIC SPRINGS
ATTICA ARTESIAN WELL
LODI ARTESIAN WELL
MINERAL SPRINGS
MONTEZUMA ARTESIAN WELL
MINERAL WELL
MINERAL SPRINGS
SPICELAND MINERAL SPRINGS
MINERAL SPRINGS
GREENWOOD MINERAL WELL
ARTESIAN WELL
EXCHANGE MINERAL WELL
MAGNETIC MINERAL WELL
MARTINSVILLE MINERAL WELLS
GOSPORT ARTESIAN WELL
SPENCER ARTESIAN WELL
CREEK SANITARIUM
NASHVILLE ARTESIAN WELL
COLUMBUS MINERAL WELL
MILAN MINERAL WELL
WHITE CRANE MINERAL SPRINGS
SEYMOUR ARTESIAN WELL
INDIAN SPRINGS
LASALLE SPRINGS
TRINITY SPRINGS
ELLIOTT SPRING
WEST BADEN SPRINGS
FRENCH LICK SPRINGS
RHODES MINERAL SPRINGS
PAOLI SULPHUR WELL
LAMBDEN SULPHUR SPRING
COATES SPRING
PAYNES MINERAL SPRINGS
MINE MINERAL SPRING
SWEET SULPHUR SPRINGS
HAZELWOOD SULPHUR WELL
WHITE SULPHUR WELL
CORYDON SULPHUR WELL
ASH IRON SPRINGS
MINERAL WELL
MAP SHOWING LOCATION OF IMPROVED MINERAL WELLS AND SPRINGS IN INDIANA
WELLS AND SPRINGS WITH HOTELS OR SANITARIA
WELLS AND SPRINGS WITH MINOR IMPROVEMENTS

Fig. 5.

Figure 5 shows the distribution in Indiana of the mineral wells and springs which have been used commercially. These are also more common in the southern half of the state. This is partly due to the greater frequency of mineral springs and wells in that section of the state and perhaps in part to the fact that population came into Indiana largely from the south. Hence most of the natural mineral water sites were first developed in that section.

About half of the mineral waters of Indiana come from either natural springs or wells dug or drilled for water, and half from wells which were drilled for oil or gas. The oil and gas boom in Indiana in the eighties and nineties resulted in the discovery of many mineral wells which were later developed commercially for their mineral water. Of the fifty-one localities in Indiana where commercial development of mineral waters took place slightly less than half were discovered in drilling for oil or gas.

The mineral waters come from a wide range of geological formation. Table I gives the age of the geological formations from which the water is obtained at each of the forty-one places in Indiana where health resorts were developed. The exact geological horizon is not determinable in many cases, so it was thought best merely to give the geological age of the source rock. It will be noted from an examination of this table that the various geological systems of rocks present in Indiana rank in the following order: Mississippian, Quatenary (Glacial), Silurian, Ordovician, Pennsylvanian, and Devonian. For all mineral wells and springs in the state the rank is somewhat similar. Of the 150 known mineral wells and springs in the state the approximate geological horizon of the mineral waters was ascertained for ninety-three. Following is the rank of the various geological rock systems in Indiana as producers of mineral waters:

Mississippian	33
Silurian	23
Quaternary (Glacial)	14
Ordovician	11
Pennsylvanian	6
Devonian	6
Total	93

Among the more common geological formations which yield mineral waters are the St. Louis and St. Genevieve limestones of Mississippian age, the Niagaran limestones of Silurian age, the St. Peter sandstone of Ordovician age, the Trenton limestone of Ordovician age, the Borden sandstones of Mississippian age, and glacial gravels of Quaternary age.

Larger Resorts

Space does not allow the discussion of each of the resorts separately but a few of the larger and more famous ones may be mentioned. Among these would be French Lick and West Baden at which hotels of over 700 rooms each were built. (It may be stated parenthetically that the largest hotel at West Baden was given by its owner in 1934 to the Jesuits

who now operate it as West Baden College. Since then the former Homestead Hotel has changed its name and operates now as the West Baden Springs Hotel.) Other sizeable hotels were built at Indian Springs, Milan, Dillsboro, Mudlavia, White Sulphur, Martinsville (at which place seven sanitaria were built), and Kneipps Springs.

Conclusions

While the health resorts in Indiana have had a very illustrious past, their future does not appear very bright. A glance at Figure 1 will lead one to conclude that if the trend of the past two or three decades continues it may not be long until most of them will be gone or changed into some other type of organization. In fact, even now at several of those which are still operating, the mineral waters and baths constitute minor attractions. They are rapidly becoming ordinary hotels or places where excellent cuisine and recreational facilities attract people over week ends or on Sundays and holidays. A few of the smaller places are catering largely to elderly people who wish to seek occasionally a place of quiet and rest away from the strenuous life in the city.

MATHEMATICS

Chairman: Cora B. Hennel, Indiana University

Wm. E. Edington, DePauw University was elected chairman for 1941.

ABSTRACTS

Some metric spaces into which pseudo-planar-quintuples can be congruently imbedded. Paul M. Pepper, University of Notre Dame.—A pseudo-planar-quintuple is a set S of five points and mutual distances such that (1) S is not congruent to any five points of the Euclidean plane, and (2) each four-point subset of S is congruent to a set of four points in the Euclidean plane. This paper deals with certain convex metric spaces into which these pseudo-planar-quintuples can be congruently mapped. A first metric space, convex in the sense of the metric, is formed by three Euclidean half-planes, joined along their boundary lines and metricized so that the distance between two points in the same leaf is the Euclidean metric in that half-plane, and the distance from a point in one leaf to a point in another is the minimum of the sum of the distances from the two given points to a common point on the line of junction. Into this space all pseudo-planar-quintuples are imbeddable.

A second type of convex metric space into which a two-parameter family of pseudo-planar-quintuples is congruently imbeddable can be formed by joining two congruent triangles of the Euclidean plane along corresponding edges, retaining the Euclidean metric between points in the same face of the dihedron so formed and assigning to two points, one in each face, the distance equal to the minimum of the sum of their distances from a common point on the edge of the dihedron. And what is perhaps more important is that each pseudo-planar-quintuple is congruently imbeddable into at least one such triangular dihedron.

Cubic hypersurfaces symmetric with respect to hyperplanes of a linear system. Darrell R. Shreve, Purdue University.—This paper gave a discussion of the determination of the finite number of hyperplanes of linear systems of dimensions 1, 2, 3, , $r+1$, with respect to which the cubic hypersurfaces in projective space of r dimensions can by symmetric. The finite numbers of coplanar and non-coplanar generalized Eckardt points on the hypersurface for $r = 4, 5, 6, 7, 8, 9$, are determined.

Variations of the Peaucellier cell and other linkages. M. H. Ahrendt, LaPorte.—The standard arrangement of the Peaucellier cell consists of a rhombus attached to two bars equal to each other but either longer or shorter than the bars composing the rhombus. Thus we have two standard arrangements, the positive form and the negative form. An analysis of the cell, however, shows that it is possible for it to take many other forms. The Peaucellier cell may be thought of as being composed of a kite and a spearhead. Any combination whatever of these two linkages which will keep them equally deformed and the lettered

points collinear will have the same properties as the standard cell. Furthermore, it is not necessary that the kite and spearhead be made of the same dimensions. Either part may be enlarged or diminished in size. More surprising yet, it is not necessary that any form of the cell be symmetrical with respect to a line through the collinear points. Either side of any form of the cell may be elongated. Thus it is possible to produce a cell which, instead of being composed of bars of two lengths, has no two equal bars or segments. Models of several forms of the cell have been constructed and were demonstrated. Eleven models of linkages were demonstrated two years ago. It is possible to demonstrate now several additional ones; namely, two or three 7-bar straight-line models; two models each capable of drawing all the conic sections; models for tracing the lemniscatoid, ellipse, and cardioid; and a model for finding the cube root or the cube of a number.

A three dimensional blackboard. O. H. OLSON, Valparaiso University. —The blackboard consists of three pieces of five-ply plywood, each two feet square. These three are hinged together to form three mutually perpendicular faces. The inside surfaces of the three boards are finished with three coats of liquid slate upon which two inch cross sectioning is drawn in white paint. An auxiliary square board, two feet on a side and finished as above with a handle on the other side, completes the apparatus. The author claims nothing original in this blackboard, but has found a definite need for such an apparatus in his teaching and has failed to find anything on the market to fill that need.

The comparative factor in measurement. WALTER O. SHRINER. Indiana State Teachers College.—This was a report of a study to determine the influence that a large number of student-examination papers have on the reliability of teachers' marks. Subjective type examinations of one hour length were given twenty-five students in algebra, English, and geometry, respectively. In the statistical treatment of the data a "best set of marks" for each set of papers was obtained by computing the arithmetic mean of the grades given by the twenty-five teachers on each of the papers. Each teacher's set of marks was then correlated with the "best or mean set of marks". The studies in algebra, English, and geometry, were in reality independent studies since they involved different sets of students and different sets of teachers. An analysis of the correlation coefficients in each of the studies showed that there existed little difference in the ability of algebra, English, and geometry teachers to grade their respective sets of papers accurately. The coefficients of correlation were practically all above .800 and many of them above .900. This would indicate that most teachers are quite able to rank student-papers with a high degree of accuracy when they have at least twenty-five papers for rating purposes. However, the study revealed that these teachers did not use the same scale in their ratings. Some teachers, although ranking the papers with high degree of accuracy, were consistently high graders while others, equally reliable in ranking papers, were low graders. There were also some teachers who spread their marks from "extreme high" to "extreme low". There also appeared

wide differences in judgment as to how many of the papers were to be considered "failing papers". The chief conclusion to be drawn from the study is that while teachers can rank student-papers with a high degree of accuracy, they need to give more attention to the determination of reasonable standards of achievement, when using the non-standardized type of examinations.

Operational methods for solving certain differential equations. JONATHAN D. YOUNG, Muncie.—This paper gives a discussion of the use of symbolic operators in solving differential equations. The method is applied to homogeneous differential equations of various linear types. Applications of the two basic theorems, the "shifting theorem" and the extended Leibnitz rule, were demonstrated.

PHYSICS

Chairman: J. F. MACKELL, Indiana State Teachers College

R. E. Martin, Hanover College, was elected chairman of the section for 1941.

ABSTRACTS

Theory of production of slow mesotrons. J. F. CARLSON, Purdue University.—Using the mesotron theory of nuclear forces as a basis, the effective cross section for the production of a mesotron in a collision between nuclear particles is calculated for the case that the excess kinetic energy of the nuclear particles above the threshold value is small. In this limit it is found that this cross section can be expressed as a constant times the ratio of the excess energy to the rest energy of the mesotron raised to an integral power. The power to which this ratio is raised depends on the type of interaction assumed between the heavy particle and the mesotron field. From the accepted numerical values of the quantities entering the expression, it is found that the constant has a value of about $10^{-31}cm^2$. It thus seems unlikely that any method for producing nuclear particles of high energies artificially will be efficient in producing slow mesotrons.

The structure of liquid nitromethane. G. C. DANIELSON and K. LARK-HOROVITZ, Purdue University.—From Fourier analyses of the X-ray diffraction pattern of liquid nitromethane, different distribution curves in the liquid have been determined. The electron and atomic distribution curves show that the first and second atomic neighbors are fixed by the distance of the atoms in the molecule as determined from the electron diffraction pattern of the gas. As indicated by the distribution curve, their distances are, therefore, not subject to statistical fluctuations. The number of first neighbors is 1.6 at 1.33A° and the number of second neighbors is 1.6 at 2.40A° which agree with electron diffraction determinations. Further concentrations of atoms are found at 3.48A°, 4.28A°, and at 5.26A°. The molecular distribution curve gives 1.9 first neighbors at 3.48A°, 2.7 second neighbors at 4.28A°, and 3.6 third neighbors at 5.26A°. The analyses of molecular distribution curves show that the flat shaped molecules have their first neighbors in parallel arrangement and not at random orientation.

A method for soil and fertilizer studies using radioactive elements. W. J. HENDERSON and U. S. JONES, Purdue University.—The fixation of phosphorus by Cecil clay, Bedford silt loam, Newton sandy loam and Crosby silt loam has been investigated by the use of the radioactive isotropes. When $Ca(H_2PO_4)_2$ containing radioactivated phosphorus was applied to the surface of the soil and washed down with water equivalent to a precipitation of 2.5 inches the penetration of the phosphorus ranged from one and one-fourth inches for the Cecil clay to about four inches for the Crosby silt loam. The addition of KCl caused the radioactive

phosphorus to move down into the soil more than where no KCl was used, while $(NH_4)_2SO_4$ had no immediate effect. The radioactive technique was used to study the movement of potassium in a Bedford silt loam. It was found that not more than five per cent of the KCl applied penetrated beyond one and five-eighths inches with a water treatment equivalent to 2.5 inches of rainfall.

A theoretical stress-strain curve for rubberlike materials. HUBERT M. JAMES, Purdue University, and EUGENE GUTH, University of Notre Dame.—A theoretical stress-strain curve has been derived for rubberlike materials built up from long-chain molecules connected into a network by cross bonds. The essential properties of rubber which our model is designed to reproduce are the approximate incompressibility of the bulk material and the flexibility of the rubber chain molecules. The stress-strain curve follows from the application of statistical mechanics. The stress-strain equation for the model was obtained. It may be used in rubber technology, for instance, to obtain the pressure-compression curve, given the stress-extension curve, and vice versa. The theoretical stress-strain curves show fair to good agreement with equilibrium stress-strain curves taken at Notre Dame and elsewhere.

A method of measuring the dielectric constant of poor dielectrics. R. R. RAMSEY and ARTHUR J. ROBERTSON, Indiana University.—A condenser filled with a poor dielectric can be represented as a good condenser with resistance either in series or in parallel. If the resistance is in series it can be measured by balancing a series bridge. The measured results are independent of the frequency of the hummer. If the resistance is in parallel with the condenser the results will vary with the frequency of the hummer. Robertson has proposed that the resistance is partly in series and partly in parallel and that a combination bridge should be used with a multivibrator in the battery position of the bridge. This involves three adjustments of the bridge; capacity, series resistance, and parallel resistance, which must be balanced at the same time. After much practice with made up unknowns containing a condenser with resistances in series and parallel a technic was developed so that a condenser containing water could be balanced at all frequencies of the multivibrator.

Temperature dependence of X-ray and electron scattering in zinc oxide. C. H. EHRHARDT and R. M. WHITMER, Purdue University.—Electron diffraction and X-ray diffraction patterns of zinc oxide powder obtained at different temperatures have been analyzed so as to measure the intensities of the different diffraction lines. It has been found that the intensity anomalies described before are not due to the temperature motion since they remained unchanged throughout the range of temperatures investigated.

New reactions yielding nucleii of type $Z = n + 1$. D. R. ELLIOTT and L. D. P. KING, Purdue University.—The existence of light nucleii of the type $Z = n + 1$ are of theoretical interest; one can predict the upper limit of the position spectrum or determine the nuclear radius. New reactions of this type have been observed. The half lines of nucleii

were observed by means of a multiple scale geiger countercircuit. The data were recorded by an electrically driven Sept camera tripped at intervals of from 0.4 sec to 1 sec.

The absorption spectrum of monobromobenzene. I. WALERSTEIN, Purdue University.—An investigation of the absorption spectrum of monobromobenzene has been carried out using a hydrogen continuous spectrum source and an absorption cell of 50 cm length containing the vapor. Some 280 band heads have been measured in the region from 2750 A to 2420 A. A continuum sets in at about 2400 A and extends to the lower wave length region. The classification of some of the bands and the resulting energy level diagrams of the vibrational levels were shown. Further classification is dependent on intensity measurements and variations of intensity with temperature.

A new camera for the study of molecular structure of gases by electron diffraction and the interatomic distance in nitrogen. H. J. YEARIAN, Purdue University. The determination of molecular structure by analysis of the electron diffraction patterns obtained from gases and vapors has had wide application. For molecules of low molecular weight, however, two fundamental difficulties have been encountered. A camera has been built to reduce these limitations as much as possible. Using this equipment a satisfactory agreement with the completely known structure of CCl_4 is obtained. Preliminary work on N_2, as an example of one of the more difficult light molecules, gives an interneuclear distance of 1.10 A° in comparison with the band spectrum value of 1.08 A°.

The motion of a particle in general relativity. C. LANCZOS, Purdue University.—Since the discovery of general relativity by Einstein (1916), it was realized that in this theory the motion law of a particle in an external field cannot be a superimposed principle as it is in the classical field theories, but has to be a natural consequence of the field equations. Nevertheless, the establishment of a rigorous law of motion is not obvious, due to the difficulty of defining kinematical quantities in a continuous field. Recently the author succeeded in bringing an earlier attempt of his to a satisfactory conclusion. Instead of the cumbersome power series developments attempted by Einstein and Infeld the motion law can be established rigorously and in finite form. The method is based on the application of the Gaussian integral transformation to the conservation law of momentum-energy. The analysis of the solution shows that the customarily assumed "law of the geodesics" holds under rather general conditions, but an interesting exceptional case arises if the so-called Laue scalar T vanishes. In this case the Newtonian law of motion still holds but with a proportionality factor which differs from the factor deduced from the geodesic principle. This throws new light on the problem of the anomalous value for the light deflection on the limb of the sun, observed by Freundlich.

X-ray determination of the particle size of electro-deposited coatings. E. P. MILLER and C. H. EHRHARDT, Purdue University.—The particle size of electro-plated metals is particularly important because the appearance and physical properties of the finished plates are largely

dependent upon it. Since such coatings cannot be removed from their base metal without changing their original nature and because of the smallness of the particle size, X-ray methods of determining their particle size have been used. Using experimental arrangements fulfilling the requirements of the theories as closely as possible, a detailed study of the Scherrer or Kochendorfer methods of X-ray particle size determination has been made. The arrangement was used to study the particle size of the nickel coatings on brass stampings plated under actual production methods. We have shown that under the condition of sharpest focusing of the diffracted line, the Kochendorfer equation reduces to the Scherrer equation without the term for line breadth. Since the value of the particle size of a particular sample should be independent of the method of determination, we have used the Kochendorfer method to determine the particle size of a particular sample. This size was then used to determine the breadth of the diffracted lines for a more complete pattern taken with the Scherrer arrangement. A further check is provided by comparing this natural breadth with the width of the diffraction lines from the brass base metal whose particles are so large that there is little particle size broadening.

The Photoelectric Measurements of the Variation of Light from a Weak Source Superimposed Upon a Bright Constant Source

HAROLD D. WEBB, West Liberty State Teachers College,
West Liberty, W. Va.[1]

Following the total eclipse of the sun in 1932, it was suggested to the author that a method for observing the solar corona during times of bright sunshine might be possible, whereby a photoelectric cell would be the observing device.

By the proposed method a small opening would be placed in front of the photoelectric cell. This opening would act as a scanning hole, to scan the area just outside of the image of the sun produced by the telescope. This small opening would move spirally from the edge of the image of the sun outward, the center of the spiral path being the center of the sun. The light gathered by this method of scanning would fall upon the photoelectric cell. The cell would be connected to a suitable amplifier, the output of which was to control a sort of mechanical pen, spiralling syncronously with the scanning hole, which would draw the image of the corona as "seen" by the photoelectric cell.

B. Lyot[2] has developed a rather successful coronagraph at the Pic du Midi Observatory in France, in which two spectrographs and a spectroheliograph are used. Lyot's coronagraph makes no use of photoelectric cells.

The photoelectric cell has been used in astronomical connections for measuring the light of the night sky[3] and for measuring daylight[4]. For measurements of this type a direct current amplifier or an electrometer is used, the latter being preferred by the workers in the field[5].

A. M. Skellett[6] has proposed a method similar to the one proposed here. His proposal was published after considerable work on this problem had been done by the author.

The proposed method of spiral scanning would use the methods of amplification similar to those used in television. In television the cell is connected through an alternating current amplifier, so that the neon tube or kinescope[7] connected to the output side of the amplifier responds to the changes in the illumination falling on the cell. The amplifier does

[1] This paper is a part of a thesis for the Ph.D. degree in the Department of Physics in Indiana University, 1939.

[2] Lyot, B., 1932. Comptes Rendus. 194:443-446, and Zeits. f. Astrophysik. 5:73-95.

[3] Lord Rayleigh, 1929. Proc. Roy Soc. 124:395-408.

[4] Alkins, W. R. G., and Poole, H. H., 1929-30. Opt. Soc. Trans. 31. 4:233-240.

[5] Hughes and DuBridge, 1932. Photoelectric phenomena, p. 445. McGraw-Hill.

[6] Skellett, A. M., 1934. Proc. Nat. Academy of Sciences. 20:461-464; and 1940. Bell Laboratories Record. 18:162.

[7] Ramsey, R. R., 1935. Fundamentals of radio. Ramsey Publishing Company.

not respond to the total illumination falling on the cell because an unchanging light would result in a direct current input to which the amplifier would not respond.

During the first stages of this research attempts were made to study the sun's corona. A four inch lens having a focal length of twelve feet was set up horizontally on a stone slab on the side of the room. Sunlight was thrown on the lens by the use of two mirrors. The image produced by the lens was focused upon a small metal box in which there was a small opening. Behind the opening a photoelectric cell was placed. The photoelectric cell was resistance-capacity coupled to an alternating current amplifier which had a measured gain of about 56,000. This amplifier[8] consisted of two resistance-capacity coupled stages using 24A screen grid tubes. These were resistance-capacity coupled to a type 47 output tube. The screen grid voltages of the 24A tubes were made variable by means of a potentiometer arrangement. The image of the sun, about 3.4 centimeters in diameter, was allowed to "drift" over the opening over the cell, because no heliostat was available. An output meter and a loudspeaker were used to detect any amplifier response. No characteristic response was noted in the region of the corona.

When the image of the sun was allowed to drift across the metal box so that the image of a sunspot passed over the opening in front of the cell, a noise was heard in the loudspeaker which was much the same as static on a radio just before a thunderstorm. Perhaps this sort of thing might be expected, because a sunspot is a sort of storm on the sun. Sunspot images of various sizes were allowed to pass over the opening, and in each case a decided response was noted.

Of course the results were affected by the vibrations of the building and by winds. When thin clouds were passing over the sun, however, the response of the amplifier was rather small. Therefore the author believes that he is the first to listen to the "roar" produced by the variation of light in sunspots.

In order to get reliable results concerning the sunspots and in order to study the corona, it would be necessary to perform the experiment in an observatory, far removed from machinery and traffic.

Because funds were not available for the purchase of a heliostat, nor for the purchase of materials needed to construct the scanning equipment, no attempts to reproduce the corona were made. Rather, it was decided to make various tests in order to find out whether or not the proposed scanning plan was feasible.

The plan was to study the response of the photoelectric cell to changes in intensity of a varying light when the dim light was superimposed upon the light from a bright, unchanging source. The bright light was a sort of blinding light. Thereby conditions similar to bright atmospheric glare with the weak, variable coronal light mixed with it would be set up.

Characteristic intensity curves for the cells were plotted, microamperes of photoelectric current against lumens. To obtain the data

[8] The amplifier was constructed by Ivan Conrad.

for these curves the photoelectric cell was connected to a microammeter as shown in figure 1.

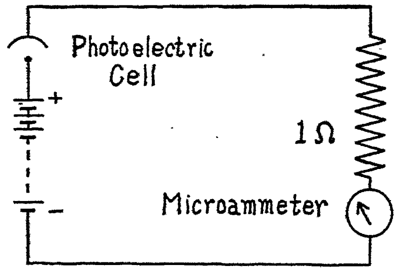

Fig. 1. Wiring diagram of the arrangement used for obtaining data for the intensity curves.

The number of lumens falling on the cell was controlled by placing a light of known candle power at various known distances from the cathode of the cell. The number of lumens falling on the cell was calculated from Ca/d^2, where C is the candle power on the source, a is the cathode area of the cell, and d is the distance of the source of light from the cell.

The curve shown in figure 2 was taken in this manner for the General Electric cell PJ23. It is typical of the curves taken for several different cells.

Fig. 2

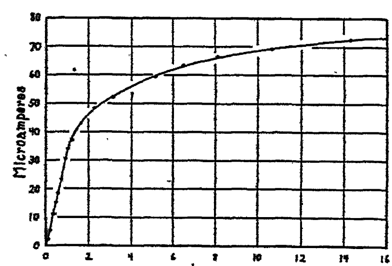

Fig. 3

Fig. 2. Intensity curve for the PJ23 photoelectric cell. The source of light was an 82 candle power, direct current source.

Fig. 3. Output curve for the PJ23 cell. The source was a 200 watt a. c. lamp.

The theory of Einstein and the work of Elster and Geitel has shown that a strict proportionality exists between photoelectric current and intensity of light over a wide range.[9] Therefore the curve of figure 2 should be a straight line. Due to the limits of the cell there seems to be a certain "saturation current", the value of which depends upon the type of cell being used.

[9] Hughes and DuBridge, 1932. Photoelectric phenomena, pp. 28 and 31.

The cell was then coupled to the previously described amplifier, and data for an output curve were obtained. The output voltages were recorded for various illuminations from an alternating current lamp. The source was, therefore, variable. The curve shown in figure 3, showing output voltages plotted against lumens, was obtained for the PJ23 cell. The output curves for other cells were similar.

From figure 3, the maximum reliable response is found at an illumination of about .6 to .8 lumens. This illumination is found to be on the straight line portion of the curve shown in figure 2.

It may be concluded, then, that if the output of the amplifier is to be reliable, the total illumination falling on the cell must be less than .8 lumens, corresponding to the straight line portion of the curve shown in figure 2.

In order to determine the response of the cell and amplifier to variable illumination, the apparatus was arranged as shown in figure 4.

The amplifier and photoelectric cell were placed in the copper box shown at A. The copper box was used as an electrostatic shield. The cell was directly behind the opening at B. The opening B was arranged to provide various sizes of openings in front of the cell. M is an output meter. S is the source of light. D is the slotted disc.

According to Talbot's law[10], which applies to photoelectric cells, if the retina of the eye is excited with periodic light, a continuous impression will result, which is the same as that which would result if the total light received during each period were uniformly distributed throughout the period.

A curve was plotted from data obtained using a 32 candle power, direct current source at S in figure 4. Output volts were plotted against lumens. The lumens were calculated by application of Talbot's law. The curve obtained is shown in figure 5.

Fig. 4

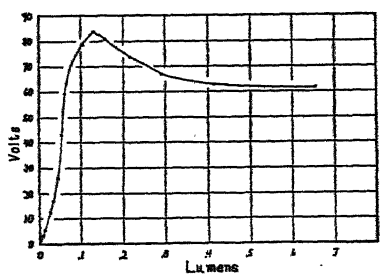

Fig. 5

Fig. 4. The arrangement of the apparatus used to get the data for the curve shown in figure 5.

Fig. 5. Output curve for the PJ23 cell, using an 82 candle power source, interrupted 50% of the time by a slotted disc. The disc was kept at 13 cm. from the opening in front of the cell. The source distance was varied.

The maximum variable illumination for reliable response is seen to be .13 lumens.

[10] Carruthers, G. H., and Harrison, T. H., 1929. Phil. Mag. 7:792-811.

In view of the curves shown in figures 4 and 5, the following conclusions were drawn. When the photoelectric cell has a constant light falling on it which brings the photoelectric current up to the point where the intensity curve begins to bend, and that constant light has superimposed upon it a light of varying intensity, the photoelectric current produced when the varying light is at its maximum brightness is not proportionally greater than the photoelectric current produced when the varying light is at a minimum; so that the variation of the photoelectric current is not as great as it would be if the total illumination at the maximum intensity of the varying light were below the intensity of light where the curve begins to bend. Therefore the output curve reaches a maximum value and then falls off, even though the total illumination and the variable illumination intensity increases. It seems that when the constant illumination is increased above a certain value the cell becomes "blinded". When the cell is used in solar observations, the total illumination falling on the cell must be kept below that certain value, which can be accomplished by varying the size of the opening over the cell. For the cell PJ23 the total illumination, including the variable illumination, must be less than .8 lumen, and the variable illumination must be less than .13 lumen when Talbot's law is applied.

A test was made to show that the cell response depended upon the total illumination falling on the cathode of the cell. The response was independent of the amount of cathode area exposed.

The intrinsic brilliancy of the sun, in candles per square centimeter, is 160,000[11]. By calculation from this datum it is found that the number
Company.
of lumens striking the earth per square centimeter is 10.9.

Abbott's measurements during the eclipse of 1908[12] show the ratios of sky light 20 degrees from the uneclipsed sun, the light from the corona at 1.5′ of arc from the limb of the sun, and the light from the corona at 4′ of arc from the limb of the sun, to the light from the sun at zenith. By calculation from these data the illuminations striking the earth per square centimeter are: from the sky at 20 degrees, 1.53×10^{-4}; from the corona at 1.5′ of arc, 1.42×10^{-5}; from the corona at 4′ of arc, 4.36×10^{-6}. The ratio of sky light at 20 degree from the uneclipsed sun to the light from the corona at 1.5′ of arc from the limb of the sun is 10.8, and to the light from the corona at 4′ of arc from the limb of the sun is 35.1. The ratio of the light from the sun at zenith to that from the corona at 1.5′ of arc from the limb of the sun is 7.67×10^{5}.

In order to find the ratios of bright illumination to weak illumination that could be detected with the apparatus being used, an 82 candle power bulb was placed near the opening B, and a 1.5 candle power bulb was placed at S, in figure 4.

Using different distances for the 1.5 candle power and 82 candle power bulbs, ratios of bright illumination to weak, variable illumination as high as 1.75×10^{5} were detectable through the cell and amplifying system. This means that the ratio of atmospheric glare to coronal light

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[11] 1938. Handbook of chemistry and physics. Cleveland Rubber Publishing
[12] Abbot, C. G., 1929. The sun. Appleton.

must be less than 1.75×10^5 to be detectable. Since the ratio, 1.75×10^5 is less than 7.67×10^5, the ratio of bright sunlight to the coronal light at 1.5′ of arc, given above, the corona would not be observable if light direct from the sun struck the cell.

The method of scanning would require, if a clear image is obtained, a very small opening over the cell. The response of the cell for different sizes of openings and illuminations was determined. For an opening $\frac{1}{16}$ inch in diameter, the smallest definite response obtained was for .0000165 lumens falling on the cell, or .000833 lumens per square centimeter. The image of the corona at 4′ of arc from the limb of the sun, produced by the four inch lens of focal length 12 feet, assuming no absorption of light, has an illumination of 3.89×10^{-5} lumens per square centimeter. .000833 is 21.4 times 3.89×10^{-5}. The area of the image necessary for observation with the $\frac{1}{16}$ inch opening in front of the cell must be 21.4 times the area of the image of the sun produced by the 4 inch lens. The image of the sun must be approximately 15.72 centimeters in diameter, or larger.

For the image of the corona at 1.5′ of arc from the limb of the sun, produced by the 4 inch lens, the illumination is 1.27×10^{-4} lumens per square centimeter. .000833 is 6.56 times 1.27×10^{-4}. The image of the sun must, then, have an area 6.56 times the area produced by the 4 inch lens. The image of the sun must be approximately 8.7 centimeters in diameter. This size image would require a telescope with a focal length of approximately 368 inches. Finer detail would require a smaller opening and a larger telescope.

Conclusions

1. In this research, the writer has made the first systematic experimental observation of the response of a photoelectric cell to a weak variable light superimposed upon a bright constant light, or blinding light.

2. The writer has found that it is possible to use a photoelectric cell to observe the variations of light from sunspots. He believes that he is the first to listen to the "roar of solar tornadoes", or to the "roar of sunspots".

3. A weak varying light superimposed upon a bright constant light 1.75×10^5 times as bright as the weak light can be detected by the methods of this research. The ratio is probably great enough to permit the observation of the corona above atmospheric glare.

4. The method proposed seems feasible, and it seems that it can be used with a telescope that produces an image of the sun 8.7 centimeters in diameter, or larger, if the $\frac{1}{16}$ inch opening is used over the cell. For finer detail a smaller opening and a larger telescope would be required.

Acknowledgment

The author wishes to use this means to thank Dr. R. R. Ramsey, who suggested the problem, for his supervision and help during the research and during the preparation of the manuscript.

Combination Frequencies and Modulation

MILO WELLS, Lakewood Ohio*

The result of combining waves of different frequencies led to a rather famous dispute commonly known as the Helmholtz-Koenig controversy. The question which arose concerned the objective reality of beat notes. One group maintained that beat tones did not exist as separate oscillations but that they were detected as such by the ear. On the other hand, the opposite opinion held that beat tones had physical existence. With the advent of radio telephony a number of years later the controversy appeared anew in discussions of the process of modulation.

The purpose of the study reported in this paper was to examine the wave pattern resulting when two sine waves were combined under such conditions as to produce modulation in an oscillating circuit. It was hoped that by employing combining waves of sufficiently low frequencies the resulting pattern could be resolved on the screen of a commercial cathode ray oscilloscope which had a linear sweep circuit.

Grid modulation was first employed. The mutual or transfer characteristic may be represented in the neighborhood of a point (E_c, I_c) by a Taylor's series as follows:

$$I = I_c + A(E - E_c) + B(E - E_c)^2 + \dots \quad \text{(I)}$$

Now suppose that we impress upon the grid two sinusoidal voltages of frequencies $f_1 = p/2$ and $f_2 = w/2$. Substituting in (I) and using the well-known trigonometric reduction formulas

$$\sin^2 a = \tfrac{1}{2}(1 - \cos 2a)$$
$$\sin a \sin b = \tfrac{1}{2}[\cos(a - b) - \cos(a + b)]$$

We have the expression for the current

$$I = I_c + \tfrac{1}{2} BE_1^2 + BE_2^2 + AE_1 \sin w t + AE_2 \sin p t - \tfrac{1}{2} BE_1^2 \cos 2 w t - \tfrac{1}{2} BE_2^2 \cos p t + BE_1E_2 \cos (w - p)t - BE_1E_2 \cos (w + p)t + \dots \quad \text{(II)}$$

There are four non-harmonic frequencies resulting and also the second harmonic of each of the parent frequencies as well as terms of zero frequency. The terms of frequency $(w - p)/2$ and $(w + p)/2$ are the side bands. The above theory assumes that the transfer characteristic is nonlinear. If the linear portion of the curve applies, all square and higher terms drop out, including also the product term so that simple addition and not modulation is the result.

These two cases are shown in figure 1. Figure 1a and figure 1d are two sine waves whose frequencies are in the ratio of 5 to 7. Figure 1b is the wave form resulting in the output circuit when the grid is biased on the linear portion of the mutual characteristic, that is in this case,

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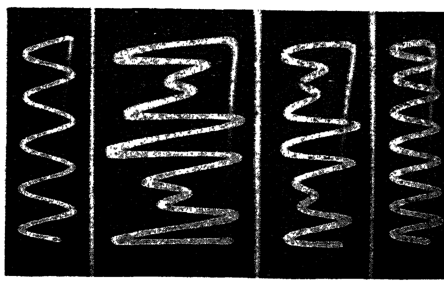
minus 3 volts. Figure 1c is the pattern resulting when the grid is biased on the non-linear portion of the mutual characteristic which is minus 9 volts. In each case the amplitudes of the combining frequencies were equal. By means of a wave meter it was determined that the only frequencies present in the output were the two input frequencies for the first case. It should be pointed out that the load was a pure resistance. In the second case, however, there were two new frequencies of 900 c.p.s. and 5400 c.p.s. in addition to the parent frequencies of 2250 c.p.s. and 3150 c.p.s. Although photographs are not shown the same thing was done with parent frequencies of 900 c.p.s. and 3150 c.p.s. That is a frequency ratio of 2 to 7.



a b c d

Fig. 1.

Next a Heising modulating circuit was set up. The current in the oscillating circuit is of the form:

$$I = AE \cos w t \qquad \text{(III)}$$

If the plate potential is made to vary sinusoidally then:

$$E = E_o + E_1 \cos p t \qquad \text{(IV)}$$

and

$$I = A(E_o + E_1 \cos pt) \cos w t \qquad \text{(V)}$$

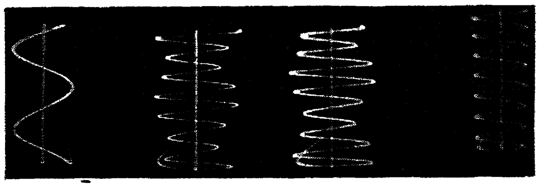
which is the equation of the curve shown in figure 2b and figure 2c. Expanding (V) and again making use of trigonometric reduction formulas, we get

$$I = AE_o \cos w t + \tfrac{1}{2} AE_1 [\cos (w-p)t + \cos (w + p)t]$$

This expression, unlike the expression for grid modulation, does not contain the modulating frequency. The tuned grid circuit across which the oscilloscope deflecting plates where connected would reject any frequency very much different from the carrier or natural oscillation frequency of the tuned circuit. For Heising modulation the carrier frequency was 30,000 c.p.s. and the modulating frequency 7,500 c.p.s., a ratio of 4 to 1.

Although the general shape of the curve is the same for figure 1 the actual frequencies which are contained in the resultant are quite different. It may be said that the amplitude of the curve shown in figure 1b varies

sinusoidally in the ratio of 7 to 2 but there is no frequency in the output corresponding to 2. For figure 1b the only frequencies in the output are in the ratio of 7 to 5. Returning now to figure 2 it will be noted that the

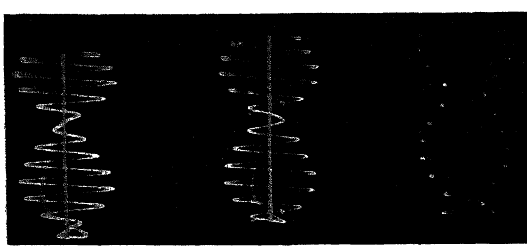


a b c d

Fig. 2.

frequency ratio is greater than 2 to 1 while the frequency ratio is less than 2 to 1 for the first case.

Figure 2 is the resultant of adding the carrier to one but not both of the side bands. This pattern was obtained by connecting the oscilloscope deflecting plates across the condenser of a wave meter loosely coupled to the tank coil of the grid circuit. The wave meter was sufficiently selective to accept any one of the three frequencies in the output, filtering out completely the other two. However, between the carrier and either side band a point could be found at which the amplitude of the carrier was equal to the amplitude of one side band or the other. Thus the patterns of Figure 3 represent simple addition and are comparable in every respect to figure 1b.



a b c

Fig. 3.

The results of the investigation may be summarized as follows:

1. The theory in regard to the formation of beat notes for sound waves has been verified for electrical waves. That is sound waves form beat notes only when combined in a non-linear medium.

2. In a similar manner electrical waves form beat notes or "side bands" only when combined in a non-linear medium. Modulation is the result of combining electrical waves in a non-linear medium.

3. A visual pattern of simple addition and one of non-linear addition appear so much alike that only an expert can distinguish between the two. As Professor Ramsey pointed out, a spectrometer such as a very selective wave meter is better adapted for the purpose.

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The Case of the Floating Needle

J. F. MACKELL and RICHARD WINN, Indiana State Teachers College

In discussing the phenomenon of surface tension, practically all textbook writers cite the fact that an ordinary sewing needle may be made to float on water, the usual inference being that forces due to surface tension account for the support of the needle. Some writers suggest that the needle should be rubbed through a slightly oiled cloth or slightly oily fingers before attempting the experiment in order that the water should not wet the needle. One might be led to infer that this slight oiling will facilitate flotation.

The above assumptions have been questioned by Frederick E. Beach,[1] and quantitative experimental evidence is cited to support an entirely opposing view. In the Beach experiment a hollow circular torus was substituted for the needle and it was shown that in this case there were three forces which contributed to the support of the torus: (1) the buoyancy due to the water displaced by the immersed portion of the torus, (2) the buoyancy due to the water displaced from the space over the bared portion of the ring, and (3) the upward components of the surface tension. Beach also contended that oiling the metal reduced the surface tension factors and cited experimental data to support his contention.

Objections have been raised to the Beach conclusions because of the nature of the oil used (oleic acid and crude oil) and because a torus was substituted for a cylindrical needle.

In view of these objections and counter-objections it was decided to reinvestigate the phenomenon and attempt to arrive at quantitative results with a cylindrical object.

First, several needles were successfully floated and the contour of the water surface was studied by magnifying glasses and photographs which were greatly enlarged. Portions of the needles were cut off in order that end views could be obtained. Due to a lack of proper facilities for making microphotographs the results obtained by this method were not conclusive.

By subsidiary tests it was ascertained that the contact angle for water on clean aluminum was essentially the same as that for clean steel. In each case the angle of contact was so nearly 90° that this value was considered approximate. Later measurements taken from enlarged photographs confirmed this conclusion.

In order that data of a quantitative character might be obtained, a hollow aluminum cylinder 10.0 cm. long and .860 cm. diameter was stopped at each end and this cylinder was found to float readily. Cross sectional photographs were made of this floating cylinder. These photographs were enlarged and projected from a slide upon a screen from which satisfactory measurements could be made. Figure 1 shows an

[1] Beach, F. E., 1928. Am. Journ. Scin. 16:

enlargement of an end view of the floating cylinder. Figure 2 illustrates the measurements which were taken from a large projection of Figure 1.

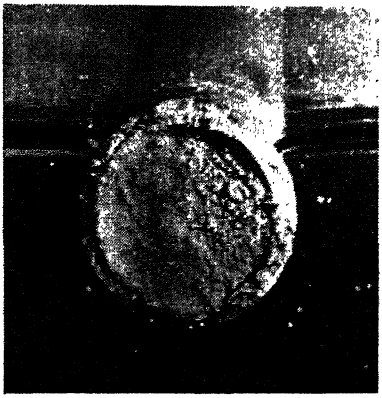

Fig. 1

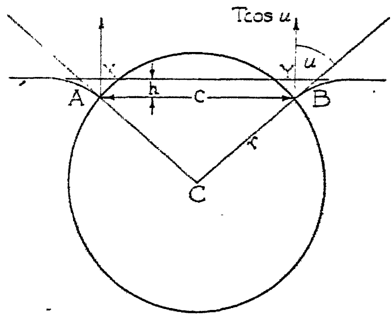

Fig. 2

It is obvious that there are three forces supporting such a floating object: (1) The buoyant force of the water displaced by the submerged portion below the chord AB. (2) The upward force due to the depth of the contact points A and B below the free surface. This is approximately equal to the weight of the water which would fill the section ABXY. (3) The upward components of the surface tension.

The data from which the calculations were made are: mass of cylinder 6.150 grams, temperature of water 70° F., giving T = .0727 g per cm., CB, the radius of the cylinder, .430 cm., arc AB = .78 cm., AX, the height of free surface above contact point, .05 cm., length of cylinder 10 cm. The angle made by the surface tension vector with its upward component, was computed from arc AB and the radius to be 51°58′.

From these data the three upward forces were computed and found to be:

(1)	Mass of water displaced by portion below AB	5.029 g.
(2)	Mass of water displaced by portion above AB	.339 g.
(3)	Upward force due to surface tension	.896 g.
	Total upward force	6.264 g.

The error is slightly over 1 per cent and is well within the expected value.

In the foregoing calculation it was assumed that the angle of contact is approximately 90°. This assumption could not have been in error by more than two or three degrees and this would not affect the results to an extent beyond experimental limitations.

As regards small solid steel needles which may be slightly oiled it may be pointed out that if the oiling could be so slight that it would not

affect the water it would be entirely possible to support the needle by the forces due to surface tension alone provided the needle has a diameter not to exceed .5 mm. For unit length of such a needle the equation for equilibrium, assuming the surface tension vector acts vertically and that the specific gravity of steel is 7.5, is

$$7.5\pi r^2 = 2\,T.$$

Assuming $T = .070$ grams per cm., we obtain $r = .025$ cm. For any solid steel needle larger than this a buoyant force must be added.

Conclusions

1. It is possible to float an oiled steel needle for a short while at least by surface tension alone if the needle is very small (.5 mm. diameter or less).

2. In most cases heavy objects floating on water are wet by the water and are thus partially supported by forces due to the displaced water and partially by the upward components of the surface tension.

3. Oiling a needle slightly will not make it float more readily but it will permit the forces due to surface tension to act unaided save for the relatively small buoyant forces due to the water displaced, and if the needle is small enough it will ride in a hollow trough as is contended by some textbook writers.

4. In most cases it is most likely that a cylindrical needle floating on water is acted upon by all three forces cited in the Beach experiment and confirmed in the present case.

5. It is recognized that a solid cylindrical needle of density seven or eight times that of water is not analogous to the case of a hollow needle such as was used in this experiment and since the needles referred to in physics textbooks are solid steel needles it is hopd that further study may be made which will throw more light on the specific case of a solid needle floating on water.

The Effect of Resistance on Dielectric Constant

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The measurement of the dielectric constant of a pure non-conducting solvent does not offer any particular difficulties and can be carried out by a number of methods. The measurement of the dielectric constant of conducting solutions is still very much a matter of controversy; even the purest solvent obtainable has some conductivity, and the reliability of the measurement decreases rapidly with increasing conductance. The accurate measurement of dielectric constant has become a matter of great importance due to its use in the determination of dipole moments and of the size and structure of a dissolved large molecule or suspended particle.

A survey of the numerical results obtained by different workers shows that considerable discrepancies exist, even in the case of pure organic liquids of low electric conductivity as has been pointed out by Davies[2]. The curves of figure 1[3] show the disagreement in the determination of the dielectric constant of KCl solutions as reported by different observers.

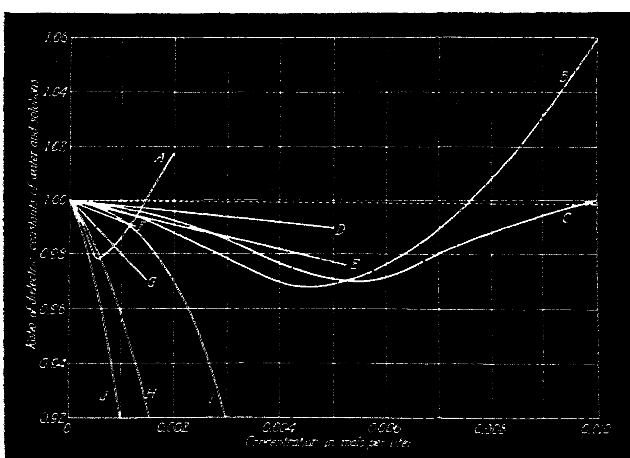

Fig. 1

The above mentioned and other existing discrepancies in the available data indicate the lack of information of the factors influencing the dielectric constant of a conducting solution. If a dielectric is a non-

[1] The work was done at Indiana University.
[2] Davies, R. M., 1936, *Phil. Mag.*, 21, ser. 7, No. 138 :37.
[3] Austin, A., 1929, *Phys. Rev.*, 34 :308.

conductor it has a zero equivalent series resistance or an infinite equivalent parallel resistance. If it is a conductor the equivalent parallel resistance has decreased, thus producing heat losses in the condenser. This pronounced heating, or loss, in a dielectric subjected to an alternating field was first observed by Siemens in 1864. The effect of the absorption is, therefore, equivalent to a resistance either in series or in parallel with the condenser.

If measurements of the capacity and resistance of a condenser are made by a bridge or a resonance method it is customary to state the results in saying that the system is equivalent to a condenser having no losses and a capacity C_p shunted by a non-inductive resistance R_p, or that it is equal to a capacity C_s in series with a non-inductive resistance R_s. Either a series resistance or a parallel resistance will change the phase angle between the electromotive force and the current. The equivalent series circuit and vector-impedence diagram for a resistance in series with a condenser is shown in figure 2. The equivalent

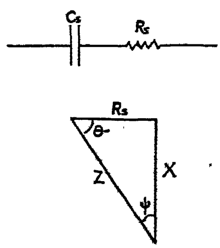

Fig. 2

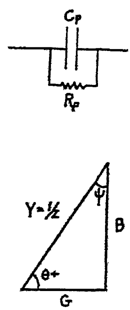

Fig. 3

parallel circuit and vector-admittance diagram for a resistance in parallel with a condenser is shown in figure 3. If the phase angle is near 90°—i.e., if the losses of the condenser are small—either a C_p or a C_s measurement will give approximately the same value for the capacitance measurement. However, if the phase angle deviates much from 90°, the values obtained by the C_p and C_s measurements will differ materially, as may be seen from the mathematical relationships which follow[4].

In the equivalent series circuit:

$$\text{Impedance} = Z = R - iX = R_s - i1/C_s\,\omega \qquad (1)$$

$$\text{P.F.} = \cos\theta = \cos[\tan^{-1}(1/\tan\Psi)] = \cos[\tan^{-1}(1/R_sC_s\omega)]. \qquad (2)$$

In the equivalent parallel circuit:

$$\text{Admittance} = 1/Z = Y = G + iB = 1/R_p + iC_p\,\omega. \qquad (3)$$

$$\text{P.F.} = \cos\theta = \cos[\tan^{-1}(1/\tan\Psi)] = \cos[\tan^{-1}(R_pC_p\omega)]. \qquad (4)$$

[4] Reference to any advanced textbook on Alternating Currents as, Hund, August, 1933, *High Frequency Measurements*, McGraw-Hill Book Co., Inc., N. Y., 4-5.

The general equations involving R, G, X, and B relating equivalent parallel to equivalent series circuits are:

$$G = R/(R^2 + X^2) \tag{5}$$
$$B = X/(R^2 + X^2) \tag{6}$$

and relating equivalent series to equivalent parallel circuits are:

$$R = G/(G^2 + B^2) \tag{7}$$
$$X = B/(G^2 + B^2) \tag{8}$$

From the above considerations the following equations may readily be derived:

$$R_p = R_s(1 + 1/R_s^2C_s^2\omega^2) \tag{9}$$
$$C_p = C_s/(1 + R_s^2C_s^2\omega^2) \tag{10}$$
$$R_s = R_p/(1 + R_p^2C_p^2\omega^2) \tag{11}$$
$$C_s = C_p(1 + 1/R_p^2C_p^2\omega^2) \tag{12}$$

It is seen from figures 2 and 3 and from equations 2 and 4 that as the power factor, P.F., varies from zero to .707, the resistance component increases in magnitude until the resistance and capacitance components are equal when the phase angle is 45°. As the phase angle varies from 45° to zero the power factor varies from .707 to 1. For a power factor equal to unity, the power loss equals EI or I^2R. In any measurement when the power factor is greater than .707 the resistance component is larger than the capacitance component, and as the power factor increases toward unity the measurement resolves into the measurement of varying resistance with the capacitative effect becoming negligible. It thus appears that a capacitance measurement holds little meaning in this region and the determination of the dielectric constant from this measurement would hardly seem reliable since the value of the capacity could change considerably without appreciably affecting the measurement.

It is also significant that, from equations 9, 10, 11, and 12, as the power factor varies from zero to .707 the values of C_s and C_p vary from equality to values where $C_s = 2C_p$, and the values of R_s and R_p vary from zero and infinity respectively to values where $R_s = R_p/2$. As the phase angle varies from 45° to zero the values of C_s and C_p approach infinity and zero respectively. Computations show that a 28% power factor denotes a variation of approximately 10% between the equivalent series and equivalent parallel capacitance. If the dielectric constant of the dielectric of such a condenser were to be computed as it is for a non-conducting solution from these measurements by setting it equal to the ratio of the capacitance of the condenser with the material as dielectric to the capacitance of the same condenser with air as dielectric it would make a 10% variation in the value of the dielectric constant depending upon whether C_s or C_p values were used. In the cases of certain conducting solutions the value of C_s is 10^3 to 10^6 times larger than

that of C_p. However, Debye's[5] generalized dielectric should be used when the phase angle deviates much from 90°.

It may be noted that there are cases in the literature where the dielectric constant for conducting solutions have been computed from C_s or C_p measurements as above set forth and not from the Debye equation, consequently the above mentioned discrepancies in dielectric constant are present. Also, when measurements are made for solutions where the power factor approaches unity the measurements become largely one of resistance.

Examples of data in which the power factor is greater than .707 are found in the literature. A typical set of data which seems to show this to good advantage, taken by Gore,[6] is shown in Table 1. This data, obtained by the bridge method at 1000 cycles per second and at 25° C., is the mean of several measurements of ortho chloro-benzoic acid solutions. This is one of several sets of data for solutions of organic acids in ethyl alcohol and benzene. Data taken by Lunt[7] and Rau on the variation of power factor and frequency shows power factors exceeding .707. Similar data reported by Hamburger[8] shows the same type of variation.

TABLE I

	Data Given			Calculated From Given Data			
Conc. mg.m/l	k_p	C_p m.f.	R_p ohms	C_s m.f.	R_s ohms	P.F.	k_s
0	24.183	.000632	41,696	.0237	40,600	.9865	912.
1	24.384	.000637	9,080	.482	9,068	.9993	185.x10^2
5	25.287	.000661	6,151	1.010	6,147	.9997	389.x10^2
10	24.740	.000647	6,613	.904	6,609	.9996	348.x10^2
15	25.214	.000660	5,144	1.442	5,142	.9998	555.x10^2
20	25.970	.000679	4,125	2.184	4,124	.9998	840.x10^2
100	34.704	.000907	1,574	11.220	1,574	1.000	4,320.x10^2

The capacity of the condenser in air was given as 26.15 m.m.f.

When a dielectric is introduced between the plates of a condenser, it is possible to account for the capacitance increase by considering that the dielectric effectively diminishes the distance between the plates. One resorts to this idea when measuring the dielectric constant of a non-conducting material, as a plate of paraffin, which does not completely fill the space between the condenser plates, in which case the equation for the capacitance is written

[5] Debye, Paul, 1929, *Polar Molecules*, The Chem. Catalog Co., Inc., N. Y., N. Y. 97.

[6] Gore, R. C., 1933. Thesis, Ind. Univ.; Published, 1936, J. Phy. Chem., 40:619-625.

[7] Lunt, R. W., and Rau, M. A. C., 1929-1930, Proc. Royal Soc., Ser. A., 126:226.

[8] Hamburger, F., 1930. Phys. Rev., 35:1121.

$$C = \frac{A}{4\pi\left[\frac{d-d_1}{k} + \frac{d_1}{k_1}\right]}$$

If a plate of poor-conducting material, such as carbon, of the same thickness, d_1, is inserted between the plates of the condenser, the capacitance is increased due to an actual decrease of d_1 in the distance between the plates. It would seem, then, that the dielectric constant of a conductor equals infinity. Here

$$C_1 = \frac{A}{4\pi\left[\frac{d-d_1}{k}\right]}$$

and the resistance of the carbon is a series resistance in the circuit.

Let us consider a condenser filled with a liquid containing dipoles which turn end for end as the potential on the plates is changed, such as when the condenser is subjected to an alternating potential. The heat effect produced by a dipole turning is essentially the same as if the current flowed through the dipole resistance a distance equal to the length of the dipole. The total effective distance would depend upon the number of dipoles present. This would cause an effective decrease of the d in the same manner as was produced by the carbon plate with the series resistance. The effective distance between the plates would depend upon the length of the dipoles and the number of dipoles present. The resistance would also depend upon the length of the dipole and the number of dipoles present. Then the resistance would be increased in proportion to the concentration of dipoles, or in proportion to the effective length of the dipoles, d_2, and the capacity of the condenser would be

$$C_2 = \frac{A}{4\pi\left[\frac{d-d_2}{k_2}\right]}$$

where k_2 remains constant and is the dielectric constant of the solution in the no-loss condition. But $(d-d_2)$ equals a certain percentage of d, the percentage depending upon the concentration of dipoles in the conducting solution, which, in turn, is also proportional to the resistance of the solution. Therefore, $(d-d_2) = d(1-F)$ where F is the percentage concentration of dipoles. Then

$$C_2 = \frac{A}{4\pi\left[\frac{d(1-F)}{k_2}\right]}$$

In a condition as just described it is logical to conclude that the resistance is in series with the capacitance. It is suggested, then, that the

dielectric constant of a conducting solution remains constant and equal to its value in the no-loss condition, and that the change in capacitance is due to the diminution of the effective distance between the plates, which, in turn, is proportional to the resistance of the solution.

A liquid containing dipoles may be likened to oil containing particles of conducting material, such as suspended carbon particles. A condition similar to the one just described is illustrated by certain measurements and assumptions made with a condenser filled with oil. Measurements of R_s and C_s employing the resonance method at 405,000 cycles per second were made on new S.A.E. number 30 crank case oil which showed very slight conductivity, then on the same oil containing suspended carbon and possibly other conducting particles. The temperature of the oil was 23° C. From these measurements it was found that by adding enough carbon to cause an increase of 1.3 ohms equivalent series resistance a 1% increase of capacity was obtained or, k remaining constant, a 1% decrease in d was produced in the constant area plate condenser. These measurements were taken in the low loss condition of the solution, therefore, the equivalent parallel resistance would be high and the values of C_s and C_p would be equal, as seen from equations 10 and 12. Then, assuming the relationship between the equivalent series resistance and the decrease in d to hold, arbitrary values of R_s were assumed and the values of C_s computed by dividing the value of C in the no-loss condition by the corresponding decreasing values of d. The values of R_p and C_p were then computed from equations 9 and 10 respectively. The values of phase angle were computed from the relationship, as seen from figure 2, $\tan \Theta = 1/R_sC_s\omega$, and the corresponding power factors determined. The partial set of data is listed in Table II. Figure 4 shows the variation of R_s with R_p, of C_s with R_p, and of C_p with R_p in Table II.

TABLE II

R_s Ohms	For % Decrease in d	d_s	C_s(m.f.)	Phase Angle	C_p(m.f.)	R_p Ohms	P.F.
0.0	0.0	1.00d	.000276	90°	.000276	∞	0.000
1.3	1.0	.99d	.000279	89°57′	.000276	1,570,000	.0009
13.0	10.0	.90d	.000307	89°25′	.000307	125,500	.0102
26.0	20.0	.80d	.000353	88°42′	.000344	50,200	.0227
39.0	30.0	.70d	.000394	87°46′	.000383	25,740	.0390
78.0	60.0	.40d	.000690	82°14′	.000678	4,258	.135
104.0	80.0	.20d	.00138	70°1′	.00103	886	.342
117.0	90.0	.10d	.00276	50°39′	.00165	291	.634
119.0	91.6	.084d	.00329	45°00′	.00165	238	.707
121.0	93.0	.07d	.00394	39°34′	.00160	204	.771
124.9	96.0	.04d	.00690	24°35′	.00119	151	.910
127.5	98.0	.02d	.0138	12°38′	.000660	133	.976
128.8	99.0	.01d	.0276	6°20′	.000338	130	.994
130.0	100.0	.00d	∞	0°00′	0	130	1.000

As may be seen from Table II or figure 4, the value of $R_s = R_p/2$ and the value of $C_s = 2C_p$ under the conditions when the phase angle equals 45°, or the power factor equals .707.

The above consideration shows how the dielectric constant of a conducting solution may be considered to remain constant and the variation in capacity all accounted for by the variation of the effective distance between the plates due to the variation in the concentration of dipole molecules or of small conducting particles, which, in turn, is proportional to the variation of resistance of the conducting solution.

The author wishes to express his appreciation to the members of the Physics Department of Indiana University for their kind cooperation and assistance and especially to Dr. R. R. Ramsey under whose guidance the problem was completed.

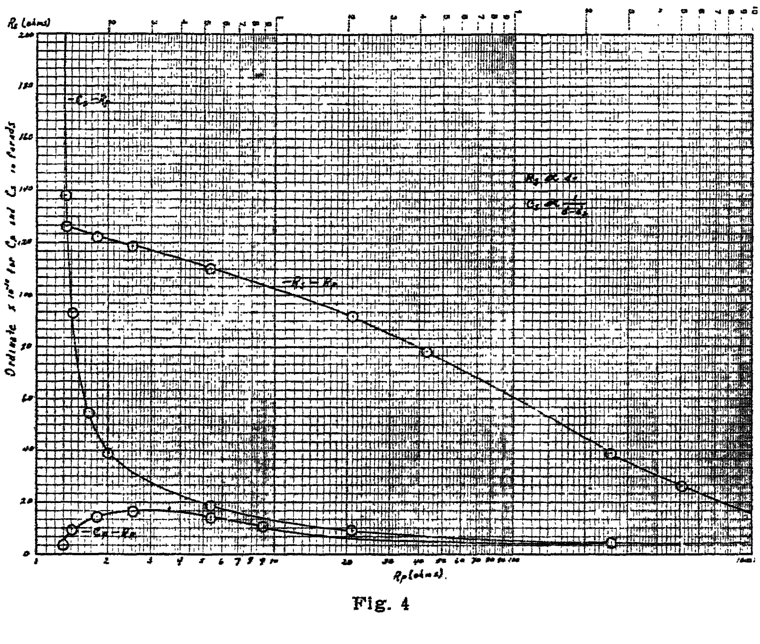

Fig. 4

PSYCHOLOGY

Chairman: R. H. ACHER, Indiana State Teachers College

H. N. Fitch, Ball State Teachers College, was elected chairman of the section for 1941.

ABSTRACTS

A study of the reactions to experimentally induced frustration. JULIAN B. ROTTER, Indiana University, and ELIOT H. RODNICK, Worcester State Hospital.—This study attempts tentatively to formulate a description of the reaction to frustration in human adults and to describe what may be considered a general experimenal method for attacking this problem. Eight male adult subjects were observed in a control situation involving the winning of money, and in a frustrating one involving the loss of money. In the analysis of results it appears that: (1) There are marked individual differences to frustration under controlled conditions and these differences seem consistent with stable personality patterns exhibited before the frustrating experience; (2) The reactions to frustration are not necessarily specific to the frustrating experience; (3) The results of this study are not consistent with such a formulation as the Yale "Frustration-Aggression Hypothesis."

Marital dominance: its effect on the child. JOHN BUCKLEW, JR., Indiana University.—On the basis of a questionnaire containing 50 items, the families of a group of 188 undergraduate college students were divided into four groups: father-dominant, mother-dominant, conflicting dominance, and non-dominant. One-half of the items referred to the father and were designed to establish the degree, if any, of father dominance. The other half of the items did the same for the mother. The odd-even reliability of the questionnaire, using the Spearman-Brown correction, was $+.75 \pm .025$. The critical ratios between high and low groups for the 50 items ranged from 2.5 to 6.7, the average C. R. being 4.2. Results would tend to show that children from father-dominant, mother-dominant and conflict families experience more difficulty in making adequate adjustments to their surroundings than those from the non-dominant families.

Studies of conditions which contributed to the withdrawal of some high school and college students. ALMA LONG, Purdue.—In her master's thesis Gleela Ratcliffe, Purdue, 1940, studied 90 non-graduating high school girl students. Results indicated that more than ⅔ of those interviewed left school for one or more of the following reasons: school was uninteresting, marriage, ill health, economic difficulties. A second survey of withdrawing women students from a college department of home economics covered a period of five years. Typical reasons for withdrawal were summarized. The distribution of withdrawals among superior students directs attention to the need of more adequate information if preventable withdrawals are to be reduced to a minimum.

Modification of the Conditioned Response Under Nembutal

CHARLES RAYMOND HEADLEE, Indiana University

Allied Investigations.—Razran (12) indicates that the use of drugs in relation to the conditioning process is one of the important factors in experimental determinations of the nature of this phenomenon. Therefore it would be wise to examine some of the more significant studies which have been undertaken in recent years, especially those in which depressant drugs were used.

There has been some research into the effects of morphine in learning situations, but these have been mostly with rats in mazes (e.g., Macht (9)), or more generally with conditioning to the repeated injection of morphine (e.g., Krilov (7)). In most cases the level of learning was lowered and extinction was facilitated. The generalized physiological effects of morphine prohibits any precise conditioning work.

Curare is fairly well localized in its effect upon the organism and has been subjected to experimentation by Culler and others. Some very interesting results were obtained. It was found by Girden and Culler (3) working on dogs with buzz-shock conditioning, that a conditioned response established in a given muscle would disappear completely when the animal was under the influence of curare, to reappear when the normal state was again reached. Culler and others (2) repeated this experiment and found essentially the same results, concluding that ". . . under the influence of the drug learning occurs at subcortical levels, which are inhibited when the cortex returns to dominance." (p. 272.)

Considerable Russian work has been done upon the effect of bromides upon the conditioning process. In general, the evidence is rather confused. Petrova and Usiyevich (11) say that individual variations to bromides (usually sodium bromide) are tremendous, but that in general a broad depression of behavior results, with larger doses being toxic and often fatal. But they say this, "Bromides are useful for developing differentiations, stabilizing extinctions, concentrating very generalized inhibitions, regulating delays in conditioned responses and preventing and curing experimental neurosis and hypnosis." (11) (Razran's translation in Psychol. Abstr.)

The most common drug of the barbiturate class is the one used in this study, namely pentobarbital sodium. It is more commonly known by the trade name Nembutal. Tests by the manufacturers have disclosed that Nembutal is identical in its effect to its chemical isomer Sodium Amytal. For general use it is a fairly safe sleep inducer, with little or no other effects if used in moderate dosages. It is commonly used as an anesthetic and may, for the present at least, be purchased at any drug store. There is some evidence that it is a habit forming narcotic.

Williams (16), working with sodium-phenobarbital, a barbiturate derivative, found that rats so drugged displayed a marked tendency to

be inferior in maze learning, and in relearning, as measured by criteria of errors and time, than the control group.

Considerable work with Sodium Amytal has been carried out to determine its effect upon the behavior of psychotic individuals and a discussion of these properties is valuable in any interpretation that may be placed on more fundamental experimental work with animals.

Black and Groulund (1), Palmer and Paine (10), and Thorner (15) found in general that Sodium Amytal used in the treatment of schizophrenics was beneficial, though temporary, in most cases. It acted largely as an anti-inhibitory agent. Lindemann (8) found that with schizoids, a minute amount of Sodium Amytal, which in normal individuals gave no change at all, caused a lifting of the pressure which he feels tends to inhibit the stuporous patient from communication with others. He also noted that the delusional ideas and hallucinations present before the drug was given were not altered significantly.

Russell and Hunter (13), working with albino rats in a maze, using subcutaneous injection of Sodium Amytal in their experimental group, found that there was no clear indication that retention of a partially learned maze was any better or any worse in the drugged rats than in the normal group.

Settlage (14) did an investigation using twelve cats and both Sodium Amytal and Nembutal. His method was the bell-shock conditioning technique. Throughout his trials no animal exhibited any signs of development of conditioning while under the influence of the drug. He describes it thus:

> "At the dosage listed the CRITICAL STATE phenomenon appeared, i.e., it was found that although there was no evidence of conditioning during the training period, learned modifications did nevertheless occur, since, when the effects of the drug has been partially or completely dissipated, conditioned responses could be elicited without further training. Thus the effect of the drug at the CRITICAL STATE was to inhibit the processes underlying the elicitation of the conditioning response without preventing the formation of new stimulus response connections." (14, p. 341.)

Statement of the Problem.—The present investigation was undertaken as an attempt to obtain more quantitative information about the learning process, as it is represented in the conditioned response method, and as it is affected by depressant drugs. Nembutal (Pentobarbital Sodium, Abbott) was selected and hypnotic dosages were used upon the dogs selected as subjects. The movements of all four feet and the respiration of the animals were recorded graphically to facilitate such quantification. Data so collected should fit into the large pattern of information concerning neural correlates of learning, and perhaps into the problem of movement and learning.

Experimental Method.—The experiment was conducted at the Indiana University Conditioning Laboratories. Six mongrel dogs were used. The conditioning technique consisted of placing a dog in a sound-proof room, in a specially prepared stock, with each foot fastened to a device which permitted the recording of movements of that foot upon a smoked record. Other connections with the dog were a pneumo-graph, electric

shock connection to right rear foot, and, within the room, a loud speaker, the onset or progress of each being recorded in the time sequence of their occurence upon the smoked record. Behavior of the animal could be observed through a one-way screen. The training series trial consisted of the presentation of the conditioned stimulus for a period of two seconds, this being a 1,000-cycle tone, 50-55 decibels above the human threshold. During the last one-fifth second of this buzz-period a shock was also presented. The shock was direct current and was adjusted to the exact voltage necessary to elicit a flexion of the shocked foot equal to four inches, the limit the apparatus allows. This procedure, repeated at intervals of from 15 to 120 seconds, for twenty times, constituted a series. Five series, or 100 trials, were given during a single day's training session. A more complete description of the technique and training process will be found in a publication by Kellogg, Davis, and Scott (6).

Nembutal was administered interperitoneally in hypnotic dosage (one half the recommended anesthetic dosage). From one to two weeks were allowed after a day's training session to allow a complete recovery from the drugged condition.

Measures were made at the nine-fifths second point, or immediately before the presentation of the unconditioned stimulus, the shock. The number of observable and measurable responses at this point, obviously due to conditioning, in any given series of twenty, was expressed as the frequency. The height of the lift of the foot in question at this same nine-fifth-second point was measured and averaged for each series of twenty trials and is reported as amplitude. Other less important measures were also made, including latency and duration of response.

The plan of the experiment was simple. Each dog was given 400 trials, covered in four different, 100 trial, training sessions, each from one to two weeks apart. Three of the six dogs used were given hypnotic dosages of Nembutal immediately before the first and third of these training sessions. The other three were given Nembutal immediately before the second and the fourth sessions. In this manner it was sought to minimize so far as possible, by direct combination, individual differences in the dog (each serving as his own control) and the effect of order within the learning process.

Results and Discussions.—Notes taken of the general observed behavior of every dog for each training session indicate a similar pattern. The usual struggle patterns were exhibited for the first series or so of the control trials, but most dogs settled down before very many trials. The situation under drug was different from this, but a general similarity was shown. A very typical picture is shown in this memorandum of dog F27: "Given 4.1 cc. of Nembutal. Soon became very unsteady in walking, almost incapable of standing up. Other behavior, as snapping at other nearby dogs, response to experimenter, etc., seemed fairly normal, but dog exhibited a marked lack of muscular control, especially as it affected her balance. Unconditioned response was constant. After being taken from the stock, she could eat standing up but staggered a bit and frequently fell from her shelf."

A quantitative measure of the amplitude of lift, of the right rear, or shocked foot, was made from each trial. Amplitude was defined as the amount of measurable lift, to the nearest one-half millimeter, which occurs at the ninth fifth-second point; i.e., nine-fifths of a second after the beginning of the buzz, and immediately before the shock. The amount of such lifts in each series was *added together* and plotted as total amplitude for each dog. The number of such possible measures within each series was then used to obtain from this total amplitude the average amplitude for that series, and these results were plotted. However, the average amplitude curves were not significantly different to warrant inclusion, especially in the face of the slightly more indicative total amplitude curves.

If the total amplitude for all six dogs be combined for each of the ten series in which drug was given, in order, and a plotting of these values compared with a similarly derived curve for the values of the ten non-drug series, upon the same set of axes, we would have a picture of the progress of this measure throughout the learning process under drug, as contrasted to progress without drug. This has been done in figure 1, for the right rear feet only. The significance of these curves lies in the

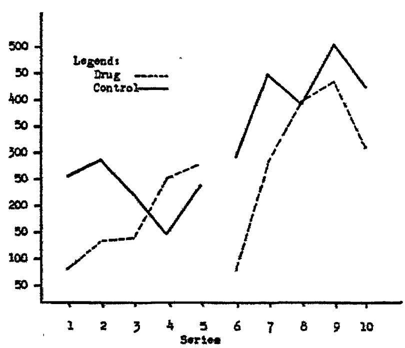

Fig. 1.

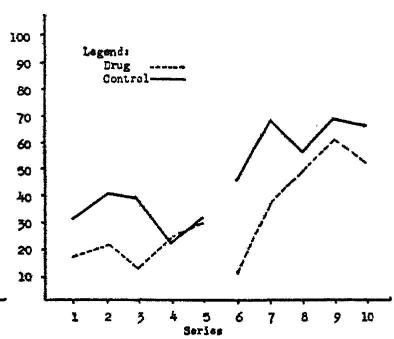

Fig. 2.

Fig. 1. Total amplitude per drug series, as contrasted with control series, for all dogs, in right rear foot only. Millimeters are represented on the ordinate.

Fig. 2. Curves showing absolute frequency under drug as contrasted with control training, for the right rear foot only. Percentages are expressed on the ordinate.

facts that: (1) there is an increase from beginning to end of the training, whether under drug or without; (2) the amount of this increase and the level which it ultimately reaches is, in general, less when the animals are under drug.

A second useful measure of the progress of learning in the conditioned response method is that of frequency. This was measured as the percentage, within a given series, of conditioned lifts occuring at the nine-fifth-second point. If now we proceed to combine the data so obtained, for all six of the dogs in terms of responses in each of the ten drug series, in order, and plot this on a graph, using the ordinate

as representative of the percentages of such responses, and the abscissa to represent the ten series, in order of their occurence, within the drugged trials, it is then possible to plot on this same set of axes identically combined data for all six dogs for the ten non-drug trials. In so far as possible, this method of combining was aimed to minimize group differences and eliminate differences due to order of presentation of the drug, so that an ordered picture of the progress of the development of the conditioned response under the influence of the drug could be compared with progress without the drug, throughout the ten series in which no drug was given, and the same for the ten drug series. This has been done in figure 2. This combination indicates: (1) that the general curve of learning, in terms of frequency of conditioned responses, approximates a sigmoid curve, both with and without Nembutal: (2) that the level of learning is lower when the animal is under the influence of Nembutal.

Data were also collected on duration, latency, retention from one training session to the next, amount of shock necessary to elicit the unconditioned response, and on defecation and urination during training. Further information on these points and a more detailed discussion may be found in Headlee (5).

Summary and Conclusions.—Six unselected mongrel dogs, purchased from an animal dealer, were conditioned to lift the right rear limb by the buzz-shock method. Each dog was given training on four different days, separated by from one to two weeks, totaling 400 trials. In three cases, or one half of the group, a hypnotic dosage of Nembutal, administered interperitoneally, was given on the first and third days; in the other half of the group, three dogs, the drugs was given on the second and fourth session of 100 trials. Recording were made of the movements of all four limbs and the conditioned lifts of each of these limbs were measured and tabulated according to absolute frequency, total amplitude, and several other measures. Curves were drawn from these data to illustrate the progress of the animal during the training. These were combined in special ways to illustrate the contrasting behavior and progress with Nembutal and without it.

1. Qualitative observations indicate a general pattern of muscular unsteadiness, staggering, waxing and waning of established associations, consistent lowering of struggle behavior, yet ability to maintain unconditioned responses and to react to the immediate environment while under the influence of a hynotic dosage of Nembutal.

2. The learning curve here found approximates the typical conditioning sigmoid curve.

3. The learning process could take place even under the inhibiting influence of a depressing drug, though at a lower level and rate with the drug, in this case Nembutal, a known cortical depressor.

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A Study of the Scholastic Trends of Fraternity Men

M. L. Fisher, Purdue University

It was the purpose of this study to determine the scholastic trend of students of Purdue University who have been pledged to and initiated into social fraternities during their freshman year.

A list of 171 freshmen was made from the fraternity membership and pledge reports and separated into five groups according to first semester indexes.

Group I	Indexed from 6.50 to 5.00 (6.5 = perfect)
Group II	Indexed from 4.99 to 4.50
Group III	Indexed from 4.49 to 4.00
Group IV	Indexed from 3.99 to 3.50
Group V	Indexed 3.49 and under

Groups were taken to contain from 25 to 45 men, and care was taken to be sure these men had become members of the fraternities during the second semester of school. The semester index of each member was then

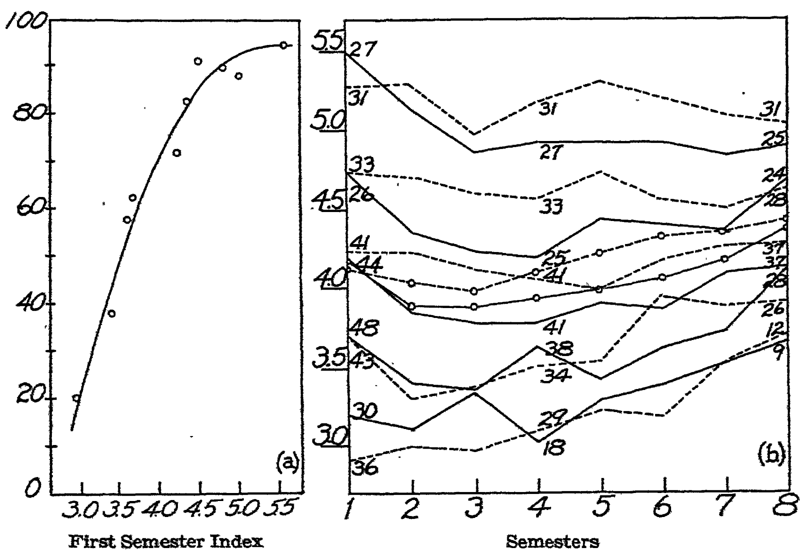


Fig. 1a. The curve shows the percentage of fraternity men that may be expected to graduate when chosen on a basis of the first semester index.

Fig. 1b. The heavy solid lines indicate the semester trends of fraternity men pledged in their first semester and made members in their second semester. The heavy dotted lines indicate the semester trends of non-organized men. Solid lines terminating in circles represent the general trend of all fraternity men. Dotted lines terminating in circles represent the general trend of all non-organized men. Small numerals indicate the number considered in each group.

found, and averages were computed for each group for each of eight semesters. Scholastic trends were plotted from these averages (Fig. 1b). Individuals who did not complete their eight semesters were considered until the time of their withdrawal. The study covers freshmen initiates of all fraternities from the first semester of 1932 through the first semester of 1935.

For purposes of comparison, non-fraternity groups of from 30 to 45 men chosen at random during the same years were studied in a similar manner (Fig. 1b).

From the data collected for the groups of fraternity men, ten divisions were made according to the first semester index, and the percentage graduating determined and plotted (Fig. 1a).

Conclusions

The first semester index should be a significant factor in choosing pledges.

In general, the index of an individual is seldom improved over that of his first semester. There are, of course, notable exceptions. The higher the scholastic index at end of first semester, the better the chances of graduating.

The Construction and Validation of a Group Home Environment Scale

W. A. KERR and H. H. REMMERS, Purdue University

It is the purpose of this study to construct a statistically valid and reliable scale for the measurement of urban home environment. The scale which results from this study should differ from the scales constructed in the past particularly in that it attempts to measure the home environment by securing the necessary information from the child, thus making unnecessary the relatively slow and expensive practice of calling individually upon each home for the desired information. This scale should be suitable for group administration in the public schools under classroom conditions similar to those under which group intelligence and achievement tests are given.

The scale is intended to be of value in psychological, sociological, and educational diagnosis of the child and in curricular and extra-curricular guidance of the child. In addition to this useful purpose, which it should be capable of serving in any school system, it should also be useful in scientific study of relationships between home environment, personality, attitudes, intelligence, and other variables.

Thus far, the scale has been used only at the high school level; it is probable that it will be found useful at the lower levels, this, of course, must be determined by further experimentation.

Construction of the scale.—Since it is the avowed purpose of this study to produce an instrument which will measure the home environment in as many of its significant aspects as is practicable, the selection of relevant items is deliberately inclusive. Yet, although the elements of home environment touched upon by these items cover a wide range, a high degree of validity for almost every item in the scale is fairly certain; this is partly due to the use in this study of the discoveries of previous scholars who have attempted to measure home environment. Naturally, items which previous research have shown to have desirable discriminating power have also been given preference in this research. A majority of the items selected are of the objective single-statement, possession-non-possession type; some are original, some gathered from previous research, and all have been evaluated by a seminar of graduate students. All of the items are questions of fact which require objective responses. Typical items are such as these:

Is there a factory, railroad, or warehouse within two blocks of your home?

Are there any flowers or shrubs in front of your home?

Is there a piano in your home?

Does your family have an automobile?

Have you ever paid money to belong to any organization such as Boy or Girl Scouts, Boys' Club, 4-H, Hi-Y, YMCA, YWCA, etc.?

Most of the items are measures of aesthetic, cultural, economic, or social aspects of the home environment. Literary content of the home is measured by items covering books, newspapers, and magazines. One part of the scale measures the cultural level of the home as indicated by the magazines taken in the home; in order to secure this latter measure, it was necessary to assign weightings to popular and representative magazines, each magazine being weighted in proportion to its own cultural value. In order to secure a cultural weighting for each magazine, a list of 101 representative magazines was prepared and given to each of 44 competent judges, each judge being directed to assign a weight of 1, 2, 3, 4, or 5 to each magazine in accordance with his opinion of the cultural value of that magazine. The split-half reliability of the ratings of these 44 judges is .96±.02SE. On the basis of the mean rating for each of the 101 magazines as assigned by these 44 judges, the cultural weights were assigned to the magazines. The 75 most representative magazines were then grouped into four cultural classes with a weight of 1, 2, 3, or 4 assigned to each magazine. In the scale, the child is directed to check each magazine taken in the home and the mean cultural weight of the magazines checked is taken as one of the more important measures of the cultural status of the home. The four classes include the following magazines. Magazines in the highest class which received a weighting of 4 include (the name of each magazine is followed by the mean rating of 44 judges):

Saturday Review of Literature 4.63, National Geographic 4.50, Harper's 4.50, Forum 4.50, Current History 4.45, Nation 4.44, Time, 4.42, New Republic 4.39, Reader's Digest 4.37, Etude 4.33, North American Review 4.21, Survey Graphic 4.19, American Mercury 4.10, School and Society 4.00, Living Age 4.00, Frontiers of Democracy 3.93.

In the second class, magazines which received a cultural weighting of 3 include:

Scientific Monthly 3.87, Scientific American 3.86, Better Homes and Gardens, 3.71, Theater Arts Monthly 3.65, Asia 3.65. Life 3.63, Nation's Business 3.63, Travel 3.58, Harper's Bazaar 3.56, Hygeia 3.54, Vogue 3.53, House Beautiful 3.53, United States News 3.52, House and Garden 3.51, American Home 3.48, Parent's Magazine 3.45.

In the third class, magazines which received a cultural weighting of 2 include:

Good Housekeeping 3.39, Ladies' Home Journal 3.39, American Magazine 3.29, Look 3.28, McCall's 3.26, Cosmopolitan 3.23, Saturday Evening Post 3.20, Woman's Home Companion 3.15, Popular Mechanics 3.14, Outdoor Life 3.11, Pathfinder 3.09, Field and Stream 3.00, Redbook Magazine 2.97, National Sportsman 2.86, Collier's 2.83, Sports Afield 2.33, Radio Guide 2.24, Physical Culture 2.15, Liberty 2.13, Photography 1.93.

In the fourth class, magazines which received a cultural weighting of 1 include:

Argosy 1.86, College Humor 1.80, Screenland 1.63, Silver Screen 1.39, Western Story Magazine 1.26, Sweetheart Stories 1.24, Real Detective Magazine 1.20, Thrilling Adventures 1.15, True Story 1.14, Thrilling Detective 1.10, Thrilling Love 1.10, Thrilling Western 1.10, Ranch Romances 1.08, True Romances 1.06, True Confessions 1.06, Breezy Stories 1.00.

Incidentally, the correlation between cultural weightings and subscription price per year for the above magazines is $.55 \pm .09$SE.

An innovation introduced in this new scale is that of the cultural and economic pictocontinuum; units on this picture continuum may be either qualitative or quantitative. A cultural pictocontinuum of four quantitative categories is used to measure the number of books in the home. Even more interesting is the economic pictocontinuum which is used to measure the quality of chairs in the home; this latter continuum contains pictures of twelve representative chairs. The assumption was made that although there are many variations in types of chairs there are probably only a few popular basic kinds of chairs; these chair types were obtained from the fall 1939 catalogue of a large mail order business and the weighting assigned to each chair was computed on the basis of the mean retail price of all chairs of its kind in the Sears-Roebuck catalogue.

Other items in the scale include measures of housing, educational status, and occupational status. Housing status is obtained by dividing number of rooms in the home by the number of persons in the home. Educational status of parents is the mean score of both parents, each parent receiving a score between 0 and 5 according to grade level reached in school. Occupational status is simply the specific occupation of the father; when the scales are scored after administration, each occupation is given a weight depending upon classification as unskilled, semi-skilled, skilled, business and managerial, or professional.

All of the items just described were divided by the authors into four categories or sections. Section I measures the aesthetic level, Section II the cultural level, Section III the economic level, and Section IV the community prestige of the home. The latter section is intended to get at an important affective factor in the home—the ascendant atmosphere of the home as indicated by presence of elements which tend to raise the prestige of the family in community, neighborhood, or ethnic group. The first section is intended to measure the presence of certain objective elements in the home which should tend to provoke attitudes of aesthetic appreciation in children. The four sections will be regrouped later according to the results of a detailed item and factor analysis.

Administration of the tentative scale.—When completed the scale was administered to a population composed of high school seniors representing approximately 1,300 homes in Gary, one of the largest cities in Indiana. This population, containing considerable racial, national, religious, political, and socio-economic diversity, is divided into seven dfferent high schools, each school differing notably from the other schools in the type of urban sociological area which it represents. Only high school seniors were used in order to exclude possible systematic differences which might be related to age of children reporting.

In each school the scale was administered to the seniors while they were gathered in a general assembly; they were given the following directions: "You are to answer the following questions about your home. Answers which you make will not influence your standing in any class

or course. Be accurate. You are to answer each question by encircling the true answer."

Investigation of methods of scoring the scale.—There are several possible methods of weighting the single statement items in the scale. The simple method is simply that of assigning one point for possession of the desirable item and zero for non-possession of the item. The differential method is based on the logical assumption that all items are not equally important or valuable to the home environment and that therefore items should be weighted in accordance with their cultural, economic, or other environment value. The sigma method is based on the assumption that desirable items which occur relatively frequently in the home environment should be weighted proportionally less than desirable items which occur less frequently. The latter method is rejected in this study because of the obvious probability that many desirable items which occur relatively frequently actually have greater cultural or economic value than many desirable items which occur relatively infrequently.

Simplicity and ease of scoring favor the simple method; however, on the possibility that a differential scoring system might yield scores significantly different from those yielded by the simple method, a differential system was worked out. Twenty competent judges were each given a list of the 65 simple-statement items in the scale and instructed to give each item two weightings of 1, 2, 3, 4, or 5 according to, first, cultural value of the item, and, second, economic value of the item. Thus two sets of mean ratings were secured for all the items. The split-half reliability of the judgments of cultural values is .89±.03SE and same for the economic values is .93±.03SE. Having obtained a set of cultural weightings and a set of economic weightings for all items, the next step was to determine whether or not the two sets of weightings were closely enough related to justify combining them into one set of environmental weightings; as a matter of fact the correlation between the set of cultural weights and the set of economic weights is .88±.03SE, which is increased to .98 when corrected for attenuation. This correlation was regarded as high enough to justify the combining of the two sets of weightings. The resulting differential weight for each item is therefore the average of the economic weight and the cultural weight

Finally, 100 of the papers from the group administration were selected at random from the entire population and each paper was scored according to, first, the simple method of scoring, and, second, the differential method of scoring. When the two sets of scores for the 100 randomly selected homes were correlated, the relationship was found to be .97±.006, which was interpreted as adequate justification for adopting the simple method of weighting as the scoring system for this home environment scale. Apparently it makes little difference which method of scoring is used except that the differential method is considerably more uneconomical to use because of its relative complexity.

Analysis and validation of the scale.—The problem of validating the scale has been attacked from two angles. Both colored and white uni-

versity women's (composed almost entirely of school teachers) organizations in the subject city volunteered to make personal calls upon a sampling of the total population of homes represented by the 1,300 scales which were scored by high-school seniors; these home-callers were instructed to go into each home, observe the home, interview a parent, and, while still in the home, fill out one of the home environment scales. Members of the white organization have at yet submitted no scales, but members of the negro organization called upon a total of 22 homes and filled out scales which may be compared with identical scales which were scored in group administration by children from the same 22 homes. The correlation between these 22 home scores and 22 group administration scores is .80±.05SE; this correlation coefficient could be raised slightly by correcting for attenuation in the criterion scores.

The second measure of validity was secured by a more unique method. First, the mean home environment score of each of the seven high schools was obtained. Six of the seven high schools had senior enrollments ranging from 150 to 274, but the seventh high school, small and in a newly developed part of the city, had only 18 seniors; with so small a population in this latter school it is probable that the mean home environment score of this school is not representative of the mean socio-economic level of the neighborhood in which the school is located; however, much greater confidence can be placed in socio-economic interpretations of data obtained from the six large schools. Second, 20 prominent school officials ranked the seven schools after reading the following directions: "You are requested to rank the seven Gary high schools in order, from 1 to 7, from the high school possessing the smallest proportion of students from homes of high socio-economic status to which you will assign a rank of 1 to the high school possessing the largest proportion of students from homes of high socio-economic status to which you will assign a rank of 7, with the other five schools being assigned ranks 2, 3, 4, 5, and 6." The reliability of these rankings from 20 judges as shown by average intercorrelation was .96. From these 20 rankings a mean ranking for each school was obtained. Finally, the mean home environment score of the schools which were obtained from group administration of the scale were correlated with the mean rankings of the schools which were obtained from the ratings of 20 judges. When the small high school of only 18 enrollment is excluded from the computations, the rank difference correlation between the group administration averages and the average judge ratings is 1.00; if the small high school is included—and there appears to be ample justification for excluding it—the correlation is lowered to .81±.11SE.

The problem of ascertaining the reliability of the scale was also attacked from two angles. First the reliability of the scale was determined by split-half techniques with a sample of 200 of the 1,300 papers. The reliability was found for each of the four sections (.37, .58, .47, and .56 respectively); using Lindquist's method of z transformations and weighting each correlation for number of items in its section an average correlation of .51 was obtained. This correlation represents the reliability coefficient of a scale ¼ the length of the present scale, therefore applying

the Spearman Brown prophecy formula to this r of .51 for a test four times longer, a reliability coefficient of .81 is obtained for the total scale. The split-half reliability for the entire scale, using the Spearman-Brown formula for a scale twice as long, is .84±.03SE.

Second, a measure of reliability was secured by isolating all twins and siblings in the total population of 1,300 and correlating these pairs of scores from the same home; 29 such pairs were obtained from the total population and the Pearson product-moment correlation for same was found to be .66±.10SE, but the interchangeable correlation was .57. However, when three poor items were dropped from the scale, this correlation was increased to .86.

Although an intensive item analysis has not yet been performed practically all items in the scale are indicated to be valid; one exception is the chair pictocontinuum which under the present mean method of scoring fails to discriminate satisfactorily; the correlation between the mean chair scores and the remaining items in the economic section is .20±.09SE. This item was dropped from the scale.

Correlations which have been computed between parts of the scale include that between the average magazine score and the total environment score with 1,304 cases, which is .45±.02SE. Correlation between occupation of father and total environment score is .59±.02SE. Correlation between total environment score and education of mother is .45±.02SE; between total environment score and education of father the coefficient is .48±.02SE. The aesthetic (I) section correlates .43±.02SE with the cultural (II) section. Aesthetic section correlates .43±.02SE with the economic (III) section. Between aesthetic section and the community prestige (IV) section, the correlation is .44±.02SE. Cultural section correlates .44±.02 with economic section. The cultural section correlates .52±.02SE with community prestige. The correlation between the economic section and community prestige is also .52±.02SE. An additional correlation between total environment score and number of children in the family yields a coefficient of —.19±.03SE.

When an intensive item analysis is completed and certain items are discarded with consequent regrouping of items, it is expected that this scale will prove to be a valuable instrument in helping to give the school a better understanding of the child as well as in assisting in the study of many variables potentially related with home environment.

ZOOLOGY

Chairman: WM. A. HIESTAND, Purdue University

W. E. Martin, DePauw University, was elected chairman of the section for 1941.

ABSTRACTS

The actions of the neurophil drugs on invertebrates. WM. A. HIESTAND, Purdue University.—A review of the bibliography of this subject is presented. The detection of reciprocal inhibition by the reversal action strychnine is discussed. Not all invertebrates show the strychnine reversal while others have been shown to exhibit a reversal of reciprocal inhibition with other drugs than strychnine. The effects of certain neurophil drugs on certain invertebrates was studied by the author with special consideration of the effects on decapod crustaceans, echinoderms, and molluscs. Crustaceans show characteristic effects on different muscle groups resulting in various postures. A mutual antagonism exists between caffeine and picrotoxin in the starfish. Great activity of the chromatophores occurs in the squid as a result of stimulation by caffeine, strychnine, picrotoxin, or atropine.

The value of a commercial meat meal as a food for Largemouth Black Bass. MARKLAND MORRIS, Earlham College, and ARTHUR HALE, Indiana University.—An attempt was made to find the effect upon the rate of growth of largemouth black bass *(Huro salmoides* Lacepede) of an artificial food. Several thousand bass fry were placed in each of six hatchery ponds. Three experimental ponds received treatments of a commercial meat meal product; three control ponds received none, and all the ponds received weekly treatments of soy bean meal to aid in the production of natural plankton food. Weekly counts of plankton, and analyses of the water for silicates, carbonates, nitrates, phosphates, oxygen, and pH were made. Biweekly samples of 50 fish were taken from each pond and weighed and measured. The number of fish put into and removed from each of the ponds was recorded. No significant difference between experimental and control ponds was found as regards the number of fish recovered, the weight of fish produced per acre, or the increase in length or weight during the period of the experiment.

An exploratory investigation of the relation of radio-activity to the automaticity of the turtle and frog ventricle. CARL D. HUCKLEBERRY, Purdue.—Rubidium may be substituted for potassium in Ringer's solution and will maintain the beating of the turtle ventricle as long as the normal potassium-containing solution. The turtle ventricle will not continue to beat in solutions in which thorium, cesium, or uranium has been substituted for potassium. Under the conditions of these experiments, the radiation from neither thorium nor uranium can replace potassium in maintaining the beating of the turtle ventricle.

Insect fauna of Steuben County. GEORGE RYAN, Angola.—The report deals with the records and studies of various insects of Steuben County which are in the Alleghenian fauna. The purpose of this work is to establish permanent records which can be used by various organizations in the state, and to make a very thorough study of the insect life in this county. This report is based upon seven years work in Steuben County. These records were obtained from the area of approximately nine square miles which comprises some of the best collecting grounds in this region. However, a large number of the records were obtained from material caught in the city of Angola.

A study of the Virginia White Tailed Deer *(Odocoileus virginianus)* **in the Allegany State Park Region, New York.** DONALD E. STULLKEN, DePauw University.—This paper is a discussion of the increasing population of the white tailed deer (*O. virginianus*) in the Allegany State Park, New York, and of its devastating effect on the deer and on the hemlock (*T. canadensis*) of this region. The paper briefly covers the evidences of the increasing population beginning with the winter of 1936-37, and finally centers the discussion on the conditions as they exist at the present time. Statistics on the death toll of deer due to starvation during the past winter, 1939-40, and an estimate of deer losses for the coming winter are given. Damage to the hemlock is described. In conclusion, the paper offers four possible methods of remedy for this situation.

Notes on the genus Wellcomia; nematoda. W. E. MARTIN and D. E. STULLKEN, DePauw University.—The geographic and host distribution of this genus of parasitic nematodes is considered. An apparently new member of the genus, parasitic in porcupines, is described.

Sexuality, sex behavior and inheritance in the unicellular animal, ***Paramecium aurelia.*** T. M. SONNEBORN, Indiana University.—The sex act in Paramecium is conjugation, in which two individuals unite, fertilize each other, and separate. Although each individual is thus functionally comparable to an hermaphrodite, it is sexually distinct in a physiological sense, for the species consists of six different mating types (I to VI). Conjugation occurs only between types I and II, between III and IV and between V and VI. The vegetative progeny of an individual of any one type are all alike, so that large cultures of each mating type are obtainable. When two such cultures (belonging to types that can interbreed) are mixed together, there is an immediate agglutination of the animals. Within the resulting clumps the animals pair off and conjugate. This sex reaction occurs under conditions of light and temperature that differ for different pairs of mating types. Among the results that have followed from these discoveries are: (1) modifications in ideas concerning sexuality; (2) revision of the concept of the "life cycle" in ciliate Protozoa; (3) discovery of lethal interactions between different races of Paramecium; (4) discovery of simple Mendelian inheritance; (5) demonstration that the periodic nuclear reorganization process commonly known as endomixis is in fact a self-fertilization; and (6) discovery of a new type of inheritance limited by genes but not determined by them.

The effect of the limitation of diet on growth in chicks and their response to prolactin injection. W. R. BRENEMAN, Indiana University.—White Leghorn cockerels were placed on a limited ration for twenty days after hatching and a study made of body, comb, gonad, pancreas, liver, thyroid, and intestine weights as well as intestine length. These animals were compared with chicks which received a normal diet and chicks in both series were also injected with Prolactin (Difco Laboratories, Inc.). A total of 193 chicks were used in this work and all weights were expressed as a percentage of body weight. Limited diet chicks were 50% lighter than the normal animals but testes and comb weights were proportionately much lighter, indicating that pituitary secretion had been inhibited. Weights of other organs were heavier in proportion to body weight than in the controls with the exception of the thyroid which did not differ significantly. Administration of Prolactin resulted in lower comb and gonad weights in normal diet birds but although the testis weight was lower, combs were slightly heavier than those of the controls in the limited diet birds. Adrenal weights were slightly greater in both series and in the normally fed animals the pancreases, liver, and intestine weights and intestine length were distinctly heavier. Thyroids appeared to be very slightly stimulated. Prolactin did not produce an hypertrophy of the viscera in the limited diet cockerels but at the heaviest dosages used (10 units daily third to nineteenth day) the thyroids were heavier than those of the controls.

Accessory motor responses in birds and mammals during panting, their central control, and modifying influences of the stretch receptors of the lungs. W. C. RANDALL and W. A. HIESTAND, Purdue University.—Accessory respiratory motor reactions occur in birds and mammals which are synchronous with breathing movements. In the duck during panting these consist of movements of the bill, tongue, and floor of the mouth. Salivation also results. In the rabbit movements of the nose flap occur synchronously with breathing movements. Tracheotomy does not abolish these accessory movements although it results in "sham" panting when the need for lowering the body temperature occurs. Inflation of the lungs during artificial respiration abolishes panting entirely in the rabbit but in the duck serves only to modify the rate by slowing it. Maintained expansion of the lungs of the duck causes a gradual slowing of respiration until apnea results. Vagotomy in the rabbit and duck abolishes the inhibitory influence of the stretch receptors and allows the panting rate to be maintained entirely by the central mechanism independently of reflex influences from the lungs. Inflation of the lungs of the muscovite duck does not reduce the heart rate either before or after vagotomy.

The life history of *Deropristis inflata* (Molin) (Trematoda: Acanthocolpidae). R. M. CABLE, Purdue University.—The adults of *Deropristis inflata* occur in the intestine of *Anguilla rostrata*. The cercaria develops in simple rediae in the digestive gland of *Bittium alternatum* and encysts in *Nereis virens*. It is a modified trichocercous form, the tail bearing 6 apposed pairs of ventrolateral tubercles, each set with a delicate "hair"; smaller irregularly distributed tubercles may occur on the distal third of the tail. A short ventral fin-fold is present. The body contains at least 8

pairs of cephalic glands with ducts both median and lateral to the eye-spots. Each main excretory tubule extends forward to the pharyngeal level where it receives an anterior and posterior collecting tubule. The anterior receives two secondary tubules, one extending forward to join the capillaries of 3 flame cells near the oral sucker, the other backward to join a similar group of flame cells between the eye-spot and ventral sucker. The posterior collecting tubule receives secondary tubules from 5 groups of 3 flame cells each, the complete excretory formula being $2 [(3+3)+(3+3+3+3+3)]$. The posterior ends of the main tubules are ciliated and the excretory vesicle contains refractile concretions. The cercaria swims almost continuously, tail first, and is strongly photo-negative. After encystment in Nereis, little growth occurs, the most noticeable changes being dispersal of eye-spot pigment and development of the fore-body spines characteristic of the adult. Since the summer flounder was found not to harbor natural infections of *D. inflata*, this fish was fed experimentally infected annelids and large numbers of young worms were recovered.

The incidence of human intestinal Protozoa and helminths among patients of a state hospital in southern Indiana. WILLIAM B. HOPP, Purdue University.—A survey was conducted at the Evansville State Hospital for the Insane to determine the incidence of human intestinal parasitic infections. A total of 842 stools from a group of 771 patients was examined. Of these individuals, 457 were males and 314 females. Each specimen was subjected to examination by both the direct smear and the zinc sulfate centrifugal flotation techniques. The parasites found, with their percentage incidences, were as follows: *Endamoeba histolytica*, 3.1; *Endamoeba coli*, 61.3; *Endolimax nana*, 30.7; *Iodamoeba butschlii*, 3.8; *Giardia lamblia*, 1.8; *Chilomastix mesnili*, 8.4; *Trichomonas hominis*, 0.1; *Trichocephalis trichiurus*, 0.3; *Strongyloides stercoralis*, 3.2; *Enterobius vermicularis*, 7.3; *Hymenolepis nana*, 0.1, and *Heterodera radicicola*, 0.1. Of the total patients examined, 579, or 75.1 per cent, were parasitized with one or more species of protozoa, helminths, or both; 556, or 72.1 per cent, were infected with protozoa; 77, or 10.0 per cent, were infected with helminths; and 56, or 7.3 per cent, were infected with both protozoa and helminths. In addition, a number of perianal scrapings, collected by means of NIH swabs, were examined. Of the 47 persons examined by this method, 3, or 6.4 per cent, were found to be infected with *Enterobius vermicularis*. In no case were negative results obtained if the person had previously been found positive by other methods. Sweepings and scrapings from floors of bathrooms and dormitories were examined for ova and larvae of helminths. Ova of *Enterobius vermicularis*, *Syphacia obvelata*, and *Heterodera radicicola* were found. Both rhabditiform and filariform larvae of *Strongyloides stercoralis* were isolated from some of the bathroom floors. From these same localities numbers of adult and larval free-living species of nematodes were also obtained. The epidemiological studies seemed to indicate that the *Strongyloides stercoralis* infections of some of these individuals may have been obtained after admission to the institution, despite rather rigid sanitary practices.

Investigations on the incidence of human intestinal parasite infections among inhabitants of rural and urban Indiana. WILLIAM HUGH HEADLEE and WILLIAM B. HOPP, Purdue University.—Microscopic examinations of stools from five groups of persons were made to determine the incidence of intestinal parasite infections. Rural groups included 185 individuals from 47 families of Montgomery, Warrick and Pike counties. Of these 185 individuals, 87 were males, 10 months to 79 years of age, and 98 were females, ranging in age from 3 months to 56 years. The parasites noted, with the percentage incidences, were as follows: *Endamoeba histolytica,* 3.8; *Endamoeba coli,* 33.5; *Endolimax nana,* 19.5; *Iodamoeba butschlii,* 2.2; *Ascaris lumbricoides,* 0.5, and *Enterobius vermicularis,* 2.2. Ninety-five, or 51.4 per cent, were infected with one or more species of protozoa, or helminth, or both. Persons examined from one of the urban areas were members of families that had children under the care of Public Health Nursing Clinics of that city. Of the 63 persons examined, 29 were males and 34 were females. Fifty-five were under 15 years of age, and 8 were older than 15 years. The infections noted, with the percentage incidences, were as follows: *Endamoeba coli,* 6.3; *Endolimax nana,* 4.8; *Giardia lamblia,* 9.5; *Enterobius vermicularis,* 1.6, and *Heterodera radicicola,* 1.6. In addition, one case of intestinal myiasis was noted. Twelve, or 19.0 per cent, were infected with protozoa, helminths or both. Stools from 12 adult persons of another urban area (from individuals attending the free city clinic), were examined for intestinal parasites. The following parasites, with their percentage incidences, were noted: *Endamoeba coli,* 16.6; *Endomilax nana,* 16.6; *Iodamoeba butsschlii,* 8.3, and *Hymenolepis nana,* 8.3. Of the 12 persons examined, 5 were found to be infected, and one of these had had a double infection of *Hymenolepis nana* and *Endamoeba coli.*

Studies on the morphology of *Cystidicola cristivomeri* sp. nov. (Nematoda: Thelaziidae), from the swim bladder of the Lake Trout. FRANCIS M. WHITE, Purdue University.—Examination of 40 specimens of *Cristivomer namaycush,* from Flack Lake, Ontario, Canada, showed all of the fish to be heavily infected with a new species of Cystidicola. Over 900 worms were removed from the swim bladder of one specimen. *Cystidicola cristivomeri* sp. nov. differs from described species of Cystidicola in body length (males 15-21 mm., av. 19.7; mature females 23-32 mm., av. 26.7); the number of caudal papillae in the male (5-7 double pairs and 1 single pair of preanal and 5 pairs of postanal papillae, the second and third forming a double pair); and egg structure, which is the most obvious characteristic of *C. cristivomeri.* The eggs lack polar filaments and when completely formed, have a pair of conspicuous longitudinal mammillate ridges which resemble superficially the floats on the eggs of anopheline mosquitoes. Such ridges have not been described for the eggs of other species of Cystidicola. Embryonated eggs of *C. cristivomeri* measure 0.043—.048 mm. in length by 0.025—.039 mm. in breadth.

Laboratory animals for research in animal behavior—a query. J. P. SCOTT, Wabash College.—A rough survey of the higher animals reveals that their behavior and social structure is closely related to the environ-

ment. Those animals which most closely resemble man are found to be diurnal in habit and living in the open water, air, or plains. The uses of certain available forms are discussed, and information regarding others is requested.

Autoplastic and homoplastic transplantation of skin in adult *Rana pipiens*, Schreber. HOWARD H. VOGEL, JR., Wabash College.—A type of skin transplant, composed of an anterior autograft and a posterior homograft, both placed within the same wound area, was used to study the incompatibility of homotransplants. Autografts usually showed good circulation within one week after transplantation.

Insects of Indiana for 1940. J. J. DAVIS, Purdue University.—A review of the major insects of the year, with special reference to those of significant economic importance, and predictions for the coming year.

Experimental factors that influence the effectiveness of ovarian follicular hormones (estrogens) in ovariectomized and normal rats. ROBERT L. KROC, Indiana University.—Three different estrogens were assayed at weekly intervals for their effectiveness in inducing vaginal cornification in ovariectomized rats. After a range of dosages were assayed, the following experimental procedures were employed with different groups: double adrenalectomy (in one or two stages) without and with 3% NaCl ad libitum, thyroidectomy, and starvation. Normal and normal-adrenalectomized rats were also treated with a range of dosages. The results indicate that removal of one adrenal is followed by no change or slight increase in vaginal responsiveness whereas removal of the second adrenal is followed by a very marked increase. This is also true of the uterine reaction. Animals receiving salt solution appear to be intermediate or nearly as sensitive as those not receiving it. Thyroidectomy or starvation also appear to increase the responsiveness but to a lesser degree than does adrenalectomy.

Abnormalities in Frog Embryos Induced by Centrifugation

T. W. TORREY and W. R. BRENEMAN, Indiana University*

Introduction

The centrifuge has long served as a tool in the experimental analysis of development of both vertebrates and invertebrates. In the early days of experimental embryology when attention was largely centered on the external environment, the eggs of many forms, including the frog, were centrifuged to determine the influence of gravity upon development. Subsequently the method was employed to bring about a redistribution of the contents of the newly fertilized but still unsegmented egg to see if any abnormality in cleavage pattern or later development resulted. The names of such pioneers as O. Hertwig and T. H. Morgan are associated with work of this sort on the frog.

To Konopacka ('08) belongs the credit for first investigating the possibility of variation in degree of abnormality, following centrifugation of frog eggs at various cleavage stages. She found that in general the number of abnormal embryos was greater when the eggs were centrifuged during the early cleavages rather than immediately after fertilization. She pictured as examples of such abnormalities numerous embryos with persistent blastopores and some headless monsters.

Konopacka's work was followed by that of McClendon ('09) who, however, was primarily interested in a chemical analysis of the various layers into which the egg contents could be separated by the centrifuge. Mention is made of McClendon only because his studies were the direct stimulus for a later investigation by Jenkinson ('14) which included a detailed description of a considerable number of abnormal tadpoles produced by centrifuging freshly fertilized eggs. These abnormalities consisted primarily of disturbances in varying degrees of anterior structures; the olfactory pits, forebrain and eyes, midbrain, skull, and mouth were either distorted or entirely lacking. In general the middle and posterior portions of the body were normal, though there were some instances of a persistent yolk-plug. There were a few monsters, in addition, resulting from excessive centrifugation, which possessed double tails as well as the usual derangements of anterior structures. These cases are especially interesting in the light of the results to be described in this paper.

Many of the results obtained by Jenkinson were not easily accounted for, coming as they did before the development of our knowledge of inductors and especially of the important role played by the roof of the archenteron in the determination of the neural tube. Jenkinson, in keeping with the times, attempted to explain most of the abnormalities in terms of mechanical difficulties imposed by abnormal distributions of

* Contribution No. 282 from Zoology Dept. and No. 85 from Waterman Institute.

yolk and fat. This was correct up to a point, but now we go much further and seek the answer in distortions in the pattern of formative movements and the dislocation of all-important organizing materials. One might, in fact, write a new interpretation based solely on Jenkinson's data to which, except for limited observations (e.g., Beams, King, and Risley, '34; Beams and King, '37), little has been added up to date. A complete redescription seems in order, however, because in the experiments to be reported, the various conditions obtained by him have been duplicated and also supplemented by many new facts.

Material and Methods

Eggs of several species of frogs as well as two species of salamanders were employed in these experiments. Since, however, the eggs of *Rana pipiens* comprised as large a portion of the total material as all the other species together, the results to be described apply solely to this form. It may be noted in passing that the fragmentary results obtained with other species differ in no essential respect from those with *Rana pipiens.*

Eggs at various stages of development were selected for centrifugation and a variety of centrifuge speeds was employed, for the purpose of identifying the most susceptible stage and the most effective speed. Any single experiment consisted in selecting a cluster of 75-100 eggs of a given stage, placing them with gelatinous membranes intact in a 12.5 cm. tube and centrifuging (Sorvall Angle Centrifuge, Type SP) at a selected speed for three minutes. Since the eggs were free to rotate in their membranes, they quickly oriented themselves with the animal hemispheres in the centripetal position as the centrifuge gained speed, and thus it may be assumed that the axis of the effective force was essentially the same for all eggs of any given stage. A total of thirty batches of eggs was treated in this fashion, of which fifteen were of *Rana pipiens.* Ten of the other fifteen groups were distributed between three other species of frogs and two of salamanders. The remaining five batches were also from *Rana pipiens*, but were obtained during the winter months by means of pituitary implants. Because of the low percentage of fertilization, these have not been included with the others. From the same mass that supplied a particular group of eggs for centrifugation a control group was also selected.

After centrifugation all groups were allowed to develop in individual three-inch stender dishes or finger bowls containing pond water which was changed daily. If the eggs continued to develop through the few hours following centrifugation, they could be expected to continue to live and to have a mortality rate no higher than the controls until their stored yolk material was exhausted. Then, because most of them had defective mouths or none at all, they died off very quickly.

A sample of, on the average, twelve eggs, both experimental and control, was fixed in Smith's modification of Tellyesnicky's fluid immediately after centrifugation for subsequent gross and miscroscopic study. Additional samples were fixed at one to three day intervals for the next ten days if the experimental larvae lived that long. Those larvae selected

for sectioning were first studied and sketched and either stained in borax-carmine before sectioning or sectioned first and stained with Harris' or Delafield's hematoxylin.

Experimental Results

Table I summarizes the fifteen groups of *Rana pipiens* eggs in terms of stage of development at the time of centrifugation, speed of the centrifuge, and subsequent developmental history. The stage numbers employed are from the table for normal development of *Rana sylvatica* (Pollister and Moore, '37).

TABLE I

Group No.	Developmental Stage	Speed of Cent. (Round Figures)	Developmental History
F-19	4-8 cells (Stage 5)............	1900 r.p.m.	Continue cleavage. Few gastrulae. Development stops.
F- 5	6-8 cells (Stage 5)............	2900 r.p.m.	No development.
F-29	16-20 cells (Stage 6+).........	1300 r.p.m.	Normal development.
F- 7	Medium Blastula (Stage 7).....	1100 r.p.m.	All embryos normal except one with defective eyes.
F- 6	Medium Blastula (Stage 7).....	1800 r.p.m.	Essentially normal. Some distortion due to diffusely distributed yolk.
F- 8	Medium Blastula (Stage 7).....	2800 r.p.m.	No development.
F-17	Late Blastula (Stage 9)........	2400 r.p.m.	Defective head and yolk mass through blastopore.
F- 1	Initial Blastopore (Stage 10)....	2500 r.p.m.	Rudimentary head; double tail.
F- 2	Initial Blastopore (Stage 10)...	2800 r.p.m.	No development.
F- 3	Initial Blastopore (Stage 10)....	2900 r.p.m.	No development.
F- 9	Crescentic Blastopore (Stage 11)	1100 r.p.m.	Normal development.
F- 4	Crescentic Blastopore (Stage 11)	2500 r.p.m.	Defective head; bud-like secondary tail.
F-10	Medium yolk plug (Stage 12)...	1800 r.p.m.	Normal development.
F-14	Medium yolk plug (Stage 12)...	2400 r.p.m.	Normal development.
F-30	Late yolk plug (Stage 12)......	2400 r.p.m.	Normal development.

An examination of this table reveals that the stage of development most affected by centrifuging as reflected by resulting abnormal larvae is that of the early blastopore, i.e., the stage at which the formative movements of gastrulation are just getting under way. (Cf. group numbers F-1 and F-4.) Although the resulting abnormalities are less pronounced, the stage immediately preceeding blastopore formation likewise appears susceptible (Group F-17). A further interesting fact about these three groups is that modification of development has followed a centrifugal speed of 2400-2500 r.p.m. That this is the most effective speed is shown by groups F-2 and F-3 where the higher speeds of 2800-2900 r.p.m. produced such distortions that further development was inhibited, an group F-9 where normal development followed the very low speed of 1100 r.p.m. The especial susceptibility of the early period of gastrulation is further emphasized by groups F-14 and F-30 where the usually effective speed of 2400 r.p.m. has failed to interfere with normal development of later stages of gastrulation. Earlier cleavage stages will continue development following the minor distortions offered by low speeds (group F-29), but moderate or high speeds (F-19 and F-5) produce displacements of materials that cannot be overcome.

Analysis of the specific abnormalities presented by the F-1, F-4, and F-17 groups, from which a total of approximately seventy-five embryos was obtained, demonstrates that no two embryos are absolute duplicates of each other. They are all featured by pronounced deficiencies and abnormalities of the head region, but each possesses particular pecularities and variations of its own. The outstanding variations of the common irregularities can best be presented by sample cases. Descriptions of six such cases follow.

Case 1. This is an individual selected from a group of embryos centrifuged at Stage 10 at 2500 r.p.m. and allowed to develop three days thereafter. These embryos attained a length of approximately 6.0 mm. and successfully hatched into free-swimming larvae. All were featured externally by a rounded, foreshortened head, distended, oedamatous abdomen, and a ventral or ventro-lateral supernumerary tail. There was no surface indication of the sense organs, nor were there oral glands or a stomodaeal pit. (Fig. 1a)

The forebrain of the embryo is confined to the limits of eight 15u sections, and at the extreme anterior end the brain wall is thick and irregular. This area is interpreted as a rudimentary telencephalon, although there are no olfactory anlagen present to assist in the identification. The floor of the telencephalon leads immediately into a diencephalon featured by an abnormally thin roof. Immediately beneath the diencephalon and connected with it by a narrow stalk lies a single optic cup (Fig. 2) with a thick retinal layer and an outer layer which is pronouncedly pigmented. There is no indication, however, of a lens rudiment. The epiphysis and hypophysis are entirely lacking.

The midbrain appears to be normal as is the anterior end of the hindbrain (first 8-10 sections). A normal pair of otocysts is associated with this normal portion of the hindbrain. But tracing posteriorly, the hindbrain gradually flattens and divides into two (Fig. 3). One of the

two hindbrains thus formed retains its regular position and is obviously the brain of the embryo proper; the other assumes a left-lateral position. In similar fashion the notochord first flattens into a diffuse mass and then divides so that each brain has a notochord associated with it. Posteriorly the lateral neural tube and notochord continue out into the supernumerary tail.

The entire pharynx is abnormal. Anterior to the tip of the notochord it exists only as a solid protrusion of endoderm abutting upon the caudal face of a mass of prechordal mesoderm. (This term "prechordal

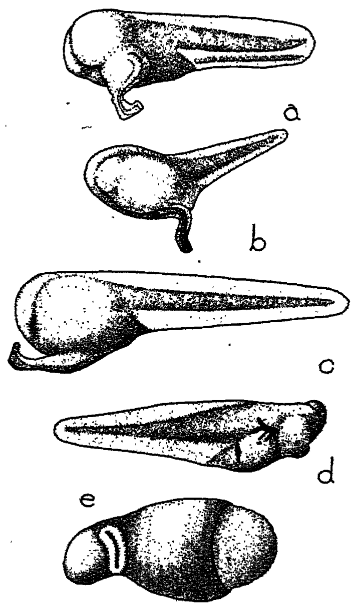
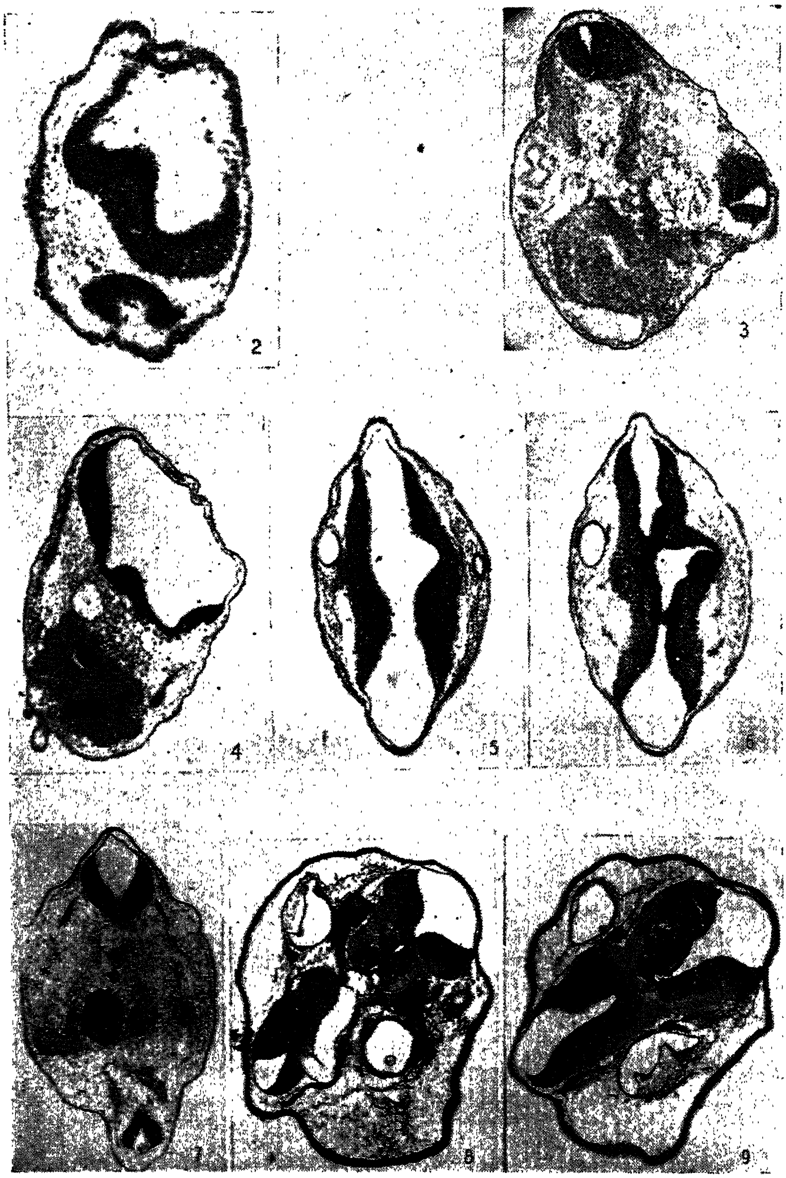


Fig. 1.

mesoderm" is being used in the general sense to include both mandibular and prechordal plate mesoderm. Cf. Adelmann '32.) From the level of the tip of the notochord back to the level of division of the hindbrain the pharynx is roughly circular and its lumen alternately open and occluded (Fig. 4). No distinguishable pouches are present.

The pharyngeal region also features very abnormal visceral and mesodermal elements. Anterior to the notochord the prechordal mesoderm exists only as an undifferentiated mass extending forward to the level of the diencephalon and occupying a strictly median-ventral position. There is no bilateral differentiation of this material at all. Posteriorly there are irregular mesenchymal condensations on each side of the pharynx which probably represent arches two, three, and four, though the absence of definitive pharyngeal pouches makes this interpretation uncertain. Rudimentary external gill filaments are present on the right side only (Fig. 4).

PLATE I



Explanation of Figures

Fig. 2. Section through anterior end of Case 1 showing cyclopean eye devoid of lens.

Fig. 3. Case 1 at level of heart, picturing secondary embryo and irregular notochordal mass on left side.

Miscellaneous structural details that might be mentioned include a normal gut posterior to the pharynx, a normal appearing heart, and a pronephros—all belonging to the embryo proper. The lateral secondary embryo has in addition to the notochord and neural tube only a complement of mesodermal somites.

To summarize, we have a cyclopian embryo accompanied by the deficiencies usually associated with such a condition; namely, reduction of the forebrain and suppression of its bilaterality, a similar suppression of the prechordal mesoderm, absence of the stomodaeum, and abnormalities of the pharyngeal region. It is extremely interesting that this embryo conforms generally and in many of its particulars to those cases of complete cyclopia in Amblystoma described by Adelmann ('34). It also offers support to Adelmann's interpretation of cyclopia in terms of suppression of bilateral development of the prechordal mesoderm. In this instance, however, the "suppression" is probably that of absence of the material rather than its failure to develop properly. It is likely, that is, that the potential "head organizer" has been dislocated by the action of centrifugal force. At one and the same time head mesoderm has largely been removed from its normal position, thus bringing about head abnormalities, and has been transferred to a new location where it has induced the formation of a secondary embryo. The exact nature of such a translocation is a problem in itself to be discussed after further data are brought forward in the cases to follow. Before leaving this case, however, there is one additional point deserving attention, namely, that the single, median optic cup has no lens.

As is well known, the extent to which lens formation is dependent upon the optic cup varies widely among the amphibia, ranging from absolute dependence in the case of forms such as *Rana fusca* to complete independence in *Rana esculenta*. *Rana pipiens*, interestingly enough, is one amphibian in which the optic cup lens relationship has not been analyzed. It would seem, however, in the light of the lens free condition existing in this cyclopian embryo that *Rana pipiens* belongs in the same category with *Rana esculenta*, otherwise the induction of a lens by the single cup would have come about. If this is true, then the potential lens ectoderm must be included with those other materials believed to have been moved during centrifugation. This point will be discussed further elsewhere.

Fig. 4. Flattened hindbrain, semisolid pharynx underlain by diffuse visceral mesoderm, and rudimentary gill filaments of Case 1.

Fig. 5. Section through elongated rhombencephalon of Case 2; note assmymetrically sized otocysts.

Fig. 6. Beginning of subdivision of brain, Case 2.

Fig. 7. Case 2. Rhombencephalon in three parts. Top, primary brain; bottom, secondary brain; middle, proximal portion of forward extending, blindly ending brain pouch.

Fig. 8. Section through Case 3, slightly posterior to figure 9, showing hindbrain separated into two, elongated notochord also dividing, and secondary otocysts. Primary brain, top; secondary brain, bottom.

Fig. 9. Beginning of division of hindbrain, Case 3. Secondary otocysts in this section.

Case 2. This embryo is one of the same group from which Case 1 was selected. It is similar in many respects to the former, but offers certain points of fundamental difference. Externally it is comparable to the previous embryo except that the supernumerary tail has a strictly ventral rather than ventro-lateral origin. Internally, however, it exhibits far greater deficiencies of the head.

The eighteenth section from the anterior end (Fig. 5) reveals an elongated rhombencephalon flanked by a pair of otocysts, the one on the left being considerably smaller than that on the right. Anterior to this level the brain is merely a thin-walled sac surrounded by scattered mesenchyme. There is no mesencephalon, prosencephalon, hypophysis, or epiphysis; there are no eyes, nasal placodes, or oral glands. Prechordal mesoderm is entirely lacking, nor is there an anterior foregut or stomodaeum.

A few sections caudad the ventrally elongated brain is roughly divided into three parts (Fig. 6). These subdivisions, connected at this level, soon separate (Fig. 7) as distinct branches of the neural tube, each underlain by a portion of the notochord. The uppermost section of the tube is that of the embryo proper and the lower one represents that part of the tube which, accompanied by the notochord, extends into the ventral supernumerary tail. The intermediate section deserves special attention because it projects backward as a blindly ending pouch lying ventral to the most anteriorly existing part of the pharynx. The latter is distorted and flattened and gives off a pair of vaguely defined and unidentified pouches. This neural diverticulum is also surrounded by an unorganized array of mesenchymal condensations representing the pharyngeal arches. The setup is very similar to a case described by Adelmann ('34) in Amblystoma in which a portion of the hypothalamus was found pushed "back into the anterior portion of the pharynx for a considerable distance, producing an intussusception of its walls" (op. cit., p. 231). In this instance, however, the diverticulum is accompanied by a notochord and except for its most proximal portion has a thin roof; thus it must be interpretated as a projection from the floor of the hindbrain rather than as an abortive forebrain. Unquestionably, then, we have an embryo entirely devoid of a forebrain and midbrain and all related and associated structures.

Other structures to be noted are the heart in the correct position relative to the primary embryo, though subnormal in size, and the pronephros possessed by both the primary and secondary embryo. This last is in contrast to the first case in which the secondary embryo did not possess a pronephros.

Posteriorly the embryo is normal except for the secondary tail which is complete with neural tube, notochord, and muscle somites.

Case 3. Case 3 is another representative of eggs centrifuged at Stage 10 at 2500 r.p.m. It was allowed to develop for six days and attained a length of 8.5 mm. Externally (Fig. 1b) it presented the familiar rounded, foreshortened head and ventral supernumerary tail, the latter arising at the anterior trunk level rather than from the head. Oral

glands, stomodaeum, and all external evidence of sense organs were again lacking.

Internally this embryo is very similar to Case 2 in that the forebrain and midbrain are entirely absent. So also are the eyes, hypophysis, and olfactory organs. There are, however, two important differences.

First, the pharyngeal region (Fig. 10) is even more reduced than in the preceding case. The pharynx occurs only as a flattened endodermal mass with an indistinct lumen and without pouches. It is impossible to distinguish definitive visceral arches and there are no external gills.

Secondly, the large hindbrain divides into two (Fig. 8) farther cephalad, and each of these hindbrains is flanked by a pair of otocysts, the secondary pair being somewhat anterior to the primary pair (Figs. 9-10). This is extremely interesting because of the possible role played by the hindbrain in bringing about the formation of otic vesicles. Stone ('31), for example, assigns to the potential medulla an important part in the induction of the otic placodes. If this is true, then the extra pair of otocysts in this embryo can be accounted for on the basis of the extra brain. The occurrence of these selfsame otocysts would thus support Stone's conclusion. It so happens, however, that whereas doubling of the hindbrain is usual for most of the embryos studied, this is the only instance of a corresponding doubling of the otocysts. As a matter of fact, the embryos customarily have a single pair only and in a case yet to be described there are none at all. It seems much more likely that the factors bringing about otocyst formation do not reside solely in the hindbrain, if at all. Harrison ('35) has concluded that the mesoderm adjacent to the prospective ear ectoderm is the primary inductor of the otocyst and this is apparently substantiated by the recent results of Yntema ('39), which show that determination of the ear ectoderm progresses considerably even before that ectoderm is contiguous to the neural folds. The determination of the ear, therefore, apparently occurs sometime during gastrulation, and the explanation of abnormalities of the otocysts in this and other embryos probably is to be found in the translocation of essential mesodermal materials as a result of centrifugation.

The heart and pericardial cavity are present, but very much reduced in size. The pronephros occurs only in the primary embryo, another point of contrast with Case 2, and, as pointed out above, the secondary tail arises from the anterior trunk region. Projecting into the accessory tail for a short distance posterior to its level of origin is a yolk-filled lobe of the intestine. Again, this secondary tail possesses a spinal cord, notochord, and somites.

Case 4. This embryo (Fig. 1c), one of a group fixed eight days after centrifuging, has been selected for brief description because of two very outstanding deficiencies not found in any of the others. First, however, mention may be made of the points of similarity to the first three cases. Once again the forebrain and midbrain regions are lacking along with all the anterior sense organs. No prechordal mesoderm is present and the visceral arches are represented only by a diffuse, shapeless

PLATE II

Explanation of Figures

Fig. 10. Case 3, posterior to figure 8, picturing primary otocysts, and flattened, partly occluded pharynx.

mass of cartilage beneath the greatly reduced and occluded pharynx. There are no pouches or gill filaments. The secondary neural tube arises from the left side of the flattened hindbrain, but gradually moves ventrally and from that position projects out into the secondary tail.

The two special defects are: (1) the heart and pericardial cavity are completely lacking; (2) there are no otocysts, either primary or secondary. For the moment no interpretation of the first is offered and the second has already been briefly considered in conjunction with Case 3.

Case 5. Case 5 has been selected from the F-4 group. The eggs of this group were centrifuged at Stage 11 and allowed to develop thereafter for slightly over three and one-half days. The tadpoles averaged 9 mm. in length at the time of sacrifice.

The embryo to be described has a short, tapering head (Fig. 1d) without oral glands, mouth or external evidence of eyes. External gill filaments are present on the right side only. The abdomen is much less oedamatous than in the previously described cases and there is no supernumerary tail. (Two other members of this group have stubby secondary tails arising from the right side of the trunk.)

The telencephalon is represented only by a cranially projecting mass of neural tissue, which is solid at the extreme anterior end but contains a lumen at about the level of transition with the diencephalon. It is impossible to distinguish cerebral anlagen, and between this abortive telencephalon and the ventrolateral somatic ectoderm only diffusely scattered mesenchymal cells intervene. The diencephalon, though less distorted than the telenchephalon, is decidedly abnormal; it occurs only in primordial tubular form without distinctive thalamic differentiation. The connection of the median-ventral eyes to its ventral floor also contributes to its abnormal character by the addition of a median ventral aperture in its floor. The midbrain and hindbrain appear to be normal.

The eyes in this embryo are represented by two optic cups fused together anteriorly and across the midline, but separate caudally. They bear a striking resemblance in their structure and relations to the diencephalon to the eyes of a 9.5 mm. Amblystoma embryo with partial cyclopia described by Adelmann (op.cit.). The retinal layers of the two cups are continuous across the midline (Fig. 11). Anteriorly the pigment layers are also continuous, but posteriorly (Fig. 12) each joins with the lateral margin of the ventral brain (optic) aperture. Especially interesting is the fact that there is a single lens only, which is associated with the right hand optic cup (Fig. 11). Furthermore, this lens is not one formed in the normal course of events, but is one which has been produced secondarily from the edge of the iris in a manner reminiscent of the known frequent cases of lens regeneration in this manner. This

Fig. 11. Case 5. Partial cyclopia, with retinal layers continuous across midline. Note small lens attached to edge of iris of right cup.

Fig. 12. Same case of partial cyclopia as above, slightly posterior. Pigment layers continuous with brain wall.

Fig. 13. Single extra otocyst of Case 5. Visceral mesoderm irregular.

Figs. 14-15. Sections through trunk, Case 6. Assymetrical spinal cord and muscle somites.

would lend further support to the point made earlier that in *Rana pipiens* the lens normally is a self-differentiating structure whose materials have, by the nature of the experimental conditions, been transferred or at least suppressed.

There is a single extra otocyst on the left side and at a level far anterior to the normal position. Its most anterior margin appears in a section at about the level of transition between the diencephalon and mesencephalon containing a diminishing fragment of the left optic cup. As Fig. 13 shows, it is well developed and is not only located abnormally far cephalad, but is also ventral to the usual otocyst position. There is no corresponding organ on the opposite side. Farther posterior and normal in both position and structure lie the regular otocysts of the embryo. The occurrence of this single abnormally located otocyst is best explained in terms of the dislocation of a mesodermal inductor (Cf. Harrison '35) because it is difficult to see how the hindbrain could play any role in the formation of an organ that occurs far anterior to that level.

The pharynx in this embryo is very abnormal, though less distorted than in the previously described cases. It terminates blindly only three sections anterior to the rostral end of the notochord and there is consequently no oral cavity. It assumes fairly regular contours from this level posterior, but there is one less pouch on the left than the right and the hyomandibular pouches are missing. The next four pouches on the right are present with the second and third opening into the opercular cavity; on the left the fifth pouch is lacking and only the second opens to the exterior. It may be pointed out in this latter connection that the internal gills and opercular cavity on the left are considerably reduced as compared with the right.

The lack of bilateral differentiation of the prechordal mesoderm is once again a striking feature. The cartilagenous mandibular arch is also absent. The hyoid and branchial arches are present, but better developed and more nearly normal-sized on the right than the left. There is a corresponding lag in the development of the branchial musculature on the left.

All body structures from the post-pharyngeal region caudad are normal.

Case 6. Case 6 has been selected primarily because it is representative of a considerable number of embryos with a persisting posterior yolk mass (Fig. 1e) and certain distortions of the spinal cord. It comes from a group centrifuged at Stage 9 and 2400 r.p.m. and allowed to develop 42 hours thereafter.

The head region is more nearly normal than in any of the previously described embryos. The most conspicuous deficiency is the absence of a stomodaeal pit and, therefore, of the hypophysis. There is only one olfactory placode, which is on the right. The oral glands are assymetrical, the one on the right being essentially normal, but the left one has the form of an elongated slit fused with the right.

The forebrain and midbrain appear normal except for distortions due to diffusely distributed yolk, the former exhibiting primary optic vesicles. The embryo is too young for the lens placodes to have developed. In contrast to the regular optic vesicles, there is a single otic vesicle only, which occurs on the right side and is still attached to its parent ectoderm. The hindbrain is regularly formed.

The spinal cord of this embryo is distinctive by being assymetrical throughout its length. Figure 14 pictures the cord at an anterior level. The right side appears normal, but the left wall is considerably thicker and its cells are continuous with a ventro-lateral wedge of cells having the appearance of a hyper-developed sensory placode or neural crest. It is to be noted, too, that the mesodermal somite on this side is considerably reduced (Figs. 14-15). This is in direct contrast to Holtfreter's ('33) observation that contact with the developing musculature causes the wall of the spinal cord to thicken. Here we have the thicker wall associated with reduced musculature.

The final point to be noted is that this embryo has a persistent blastopore through which a large yolk mass still projects to the exterior.

Conclusion

For purposes of interpretation the more outstanding irregularities described in the above cases may best be brought together under the headings of the particular organs or groups of organs involved.

1. **Pharynx, Mesoderm, and Visceral Arches:** The pharynx in cases 1, 2, 3, and 4 occurs only as a partly solid, partly tubular endodermal mass without distinguishable pouches. In case 5 it is more nearly normal, though considerably distorted, and in case 6 appears normal.

Prechordal mesoderm occurs only in cases 1, 5, and 6, showing no bilateral differentiation at all in the first and fifth and appearing normal in the last. There is no distinguishable prechordal mesoderm at all in the other three, i.e., cases 2, 3, and 4.

The visceral skeleton in the first four cases exists only as unorganized masses of mesenchyme or cartilage. In case 5 the mandibular arch is absent, but the other arches are present, though assymetrical in form. The last embryo is too young for the arches to have formed, but appears normal.

2. **Brain:** The forebrain in all cases has been affected, ranging from its complete elimination in cases 2, 3, and 4 to its essential integrity in case 6, with cases 1 and 5 being somewhat intermediate. The midbrain is likewise absent in cases 2, 3, and 4, but present and normal in the remaining three. Abnormalities of the hindbrain occur in all but the last two cases and consist of a division into two hindbrains, one primary and one secondary, with the latter continuing as a spinal cord into the supernumerary tail.

These brain abnormalities are obviously of two distinct sorts: (1) deficiency or absence and (2) duplication. Either one or both of

two causative factors may have been involved in producing these irregularities. They may be the result of either the literal removal of potential brain materials to new sites and thus to new determinations, or if such materials have not been shifted, the necessary head organizer may have been translocated.

The evidence favors the latter interpretation, for when one compares the degree of development of the brain in the several cases with that of the prechordal mesoderm, an important correlation is immediately obvious. The total absence of the forebrain and midbrain in cases 2, 3, and 4 is found paralleled by a similar total absence of prechordal mesoderm. We find a materially reduced forebrain and normal midbrain in cases 1 and 5 correlated with existing but bilaterally undifferentiated prechordal mesoderm. The normal brain of case 6 goes hand in hand with normal mesoderm. It is very probably true, therefore, that these abnormalities of deficiency are the result of translocation of the head organizer which is identified with the prechordal mesoderm. This material, located as it is in the primitive dorsal blastoporic lip, is ordinarily the first to be invaginated. Since effective centrifugation of the eggs has occurred just as invagination is beginning, it is very likely that these dorsal lip materials have been among those dislocated.

There is always the possibility, of course, that it is not the head organizer alone which has been moved, but also the associated potential brain material. Evidence will be presented in another connection that points to this likelihood as well. The alternative possibility, i.e., that the organizer materials have been left intact and the brain ectoderm has merely been removed from their sphere of influence, seems unlikely because of the occurrence of secondary embryos. That is, the presumed dislocation of at least a portion of the head organizer has not only resulted in a suppression of the forebrain and midbrain, but apparently is also responsible for the induction of a secondary embryo represented by the double hindbrain and spinal cord and supernumerary tail. It will be recalled that the secondary neural tube invariably has a notochord associated with it, which suggests that a duplication of the organizing archenteric roof has occurred. That this secondary inductor may very well be the dislocated head organizer is also suggested by observations (e.g., Spemann, '31) on the longitudinal polarity of the organizer according to which the head organizer is capable of inducing cephalic structures at trunk level.

3. **Sense Organs, Hypophysis, and Oral Glands:** Certain interpretations of conditions relating to the sense organs have already been presented in conjunction with individual cases, but some supplementary generalizations may be added.

A total absence of eyes in cases 2, 3, and 4, like the absence of the forebrain and midbrain may be the combined result of dislocation of both the medullary ectoderm and inducing substrate. If only one has been so affected, then unquestionably it is the latter.

As for the cases of complete and partial cyclopia, there is little to be added to what has already been said. The facts thoroughly support

Adelmann's interpretation of cyclopia in terms of suppression of the prechordal mesoderm. The one point of difference, namely, the absence of lenses (except for the case of unquestionable regeneration of the lens from the iris), has been discussed elsewhere. An actual translocation of lens forming materials seems to be the best answer.

The same answer must also be given for the absence of oral suckers, olfactory organs, stomodaeum, and hypophysis. As for the otocysts, however, it is undoubtedly a matter of disturbance of associated mesoderm. This aspect of the problem has already been discussed under case 3.

4. **Heart and Pronephros:** Two little is known of the manner of original determination of the bilateral heart rudiments for the results of these experiments to be completely understandable. The suppression in size, and in one case total absence of the heart, may only tentatively be accounted for on a basis of a shift of material by centrifugation.

Only in case 2 does the secondary embryo possess a pronephros. That its occurrence is undoubtedly an aspect of the general phenomenon of induction of a secondary embryo is suggested by the fact of its having been observed by many investigators. Whether a pronephros occurs in a secondarily induced embryo or not is known to depend upon the level in the host at which the inductor is working (Holtfreter, '33).

5. **Translocation of Presumptive Organ Regions:** Centrifugation obviously causes the contents of the germ to be rearranged—not all parts to the same degree, however, for the described results indicate that those materials destined to produce the anterior structures of the embryo have been most affected. Reference to Vogt's maps of the presumptive organ regions of an Anuran reveal that it is those pharyngeal and mesodermal materials that are normally first invaginated plus the ectodermal materials within the limits of the future head that are most affected. That these substances have been shifted is unquestionable, but just how and exactly where they have been moved is not so clear. One might speculate with a fair degree of accuracy on the path followed and the final position assumed by various areas under the influence of centrifugal force exerting itself parallel to the egg axis, but any conclusions derived would necessarily be tentative only and supported solely by indirect evidence. It seems best, therefore, to defer such conclusions until more direct evidence is available. This, it is hoped, will come from experiments combining the techniques of localized vital staining and regulation of the axis of centrifugal force by orientation of eggs in gelatin blocks. These results will be submitted in a later communication.

Summary

1. Eggs of the frog, *Rana pipiens*, were centrifuged at various stages of development and at various speeds. The developmental stage most affected by centrifuging, as reflected by resulting abnormal larvae, was that of the early blastopore. The most effective centrifugal speed was 2400-2500 r.p.m.

2. Numerous embryos with accessory tails and under-developed or defective heads were obtained.

3. The accessory tails possessed a spinal cord, notochord and muscle somites.

4. The head abnormalities included: (a) total or partial absence of the forebrain and midbrain and doubling of the hindbrain; (b) cases of total absence of the eyes, complete cyclopia, and partial cyclopia, the latter two featured by the absence of lenses except for one instance of lens regeneration from the iris; (c) absence of the oral suckers, olfactory organs, stomodaeum, and hypophysis; (d) variable duplications of the otocysts uncorrelated with doubling of the hindbrain, and one case of their complete elimination; (e) suppression of development of the prechordal mesoderm; (f) suppression and distortion of the pharynx and visceral arches; (g) one case of total absence of the heart and its reduced size in the other cases; and (h) one instance of an accessory pronephros associated with the secondary embryo.

5. The abnormalities have been interpreted in terms of a presumed shift of the "head organizer" by the action of centrifugal force.

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Records of Indiana Dragonflies, X. 1937-1940

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During the period 1937-1940 about 3930 specimens of Odonata representing 90 species were collected in Indiana; of these 266 specimens of 29 species were taken in 1937, 434 specimens of 50 species in 1938, 1455 specimens of 54 species in 1939 and 1796 specimens of 65 species in 1940. These collections included specimens of several rare species, some of them in considerable numbers, specimens of two species new to the state and others representing 187 new county records. All specimens are in the collection of the author, but duplicates will be distributed to private and institutional collections. All identifications have been made by the author.

Collecting during the last four years was carried on, as far as possible, in such a way as to contribute to a knowledge of the seasonal and geographical range and abundance of the species within the state. Data of these collections are given in two lists, one a list of the collections by localities and dates, the other a list of the species known from Indiana. In the list of collections the localities are arranged by counties and the species are recorded by the use of Williamson's (1917) numbers. In the list of species counties from which specimens of each were obtained in 1937-1940 are indicated. Notes on abundance, interesting observations, taxonomic notes based on specimens in the collections and other germane comments are included in both lists.

Collections for approximately the same date (half month or less) from the same collecting station, whether for one or more years, have been combined if there appeared to be no essential difference between them. Almost all of the collections were made by the author; those made by others have the name or initials of the collector(s) following the date. Collectors indicated by initials include A. W. Trippel (AWT), B. E. Heniford (BEH), B. Elwood Montgomery (BEM), Esther B. Montgomery (EBM), John J. Favinger (JJF), Lynn Robertson, Jr. (LR), Malcolm B. McDonald (MBM), Robert P. Mullett (RPM), and Virgil A. Knapp (VAK).

In the list of species, those species which have been discovered in the state since 1917 are interpolated into Williamson's list and the paper in which they were first recorded is indicated by author and date in parentheses following the species name. Species recorded from the state for the first time in this paper have the species number and name starred (*); new county records are also starred.

List of Collections made during 1937-1940

(Arranged by counties and collecting stations)

Adams. Near Decatur, June 8, 1937, (AWT), species: 43.

Allen. Along small stream near Leo, June 16, 1940, (VAK), species: 3, 58, 104, 112, 114.

Boone. Gravel pit near Sugar Creek, July 20, 1940, (EBM & BEM), species: 17, 20, 21, 22a, 29, 43; Oct. 6, 1940, species: 43.

Carroll. Lake Freeman, west of Patton, July 10, 1939, species: 3, 15, 18, 22a, 24, 29, 43, 87, 96, 99, 104, 107, 115. Tippecanoe River at Springboro Bridge, Sept. 3, 8 and 15, 1940, species: 4, 5, 15, 16, 17, 24, 25, 29, 34, 41, 43, 52, 62, 68, 70, 104, 107. The river at this point is a continuous series of ripples. At the time of the first and third visits the water was generally about one to three feet deep and many rocks were exposed; the second visit followed a rain and the water was somewhat muddy and deeper, covering many of the rocks. The gomphines were rather common on Sept. 3, flying over the ripples, alighting on exposed rocks, or, now and then, "hanging-up" in trees along the banks; on Sept. 8, they were much less common, but almost as many specimens were secured as on the earlier visit because they were found chiefly along the banks; at the time of the final visit they were quite rare, only one specimen (*E. designatus*) was taken and few others were seen. The number of individuals of the species of Argia and Enallagma decreased from one visit to the next, those of the latter more rapidly than those of the former. *Hetaerina americana* was very abundant each time but only one male of *H. titia* was seen (Sept. 3). Grassy, almost lawn-like bank of Tippecanoe River, below Oakdale Dam, Sept. 15, 1940, (LR, BEH, & BEM), species: 4, 11, 16, 17, 22a, 24, 25, 34, 41, 43.

Cass. Mud Creek, Sept. 12, 1937, species: 78—1 ♂ 1 ♀.

Clark. Francke Lake, June 10, 1940, June 15-16, 1938, species: 20, 21, 22, 22a, 33, 34, 41, 43, 44, 87, 89, 90, 96, 99, 107, 114, 115, 118; July 21-22, 1939, (EBM & BEM), species: 15, 17, 20, 25, 69, 85, 87, 96, 99, 100, 104, 105, 107, 115, 118, 119; Aug. 13, 1939, (LR, MBM & BEM), species: 15, 17, 20, 25, 41, 43, 69, 87, 96, 99, 100, 105, 107, 118. Schlamm Lake, June 10, 1940, June 14, 1937, June 14-16, 1938, June 20, 1937, species: 15, 22a, 25, 34, 43, 44, 87, 89, 90, 96, 99, 100, 104, 107, 115, 118, 124; July 22, 1939 (EBM & BEM), July 28, 1937, species: 22a, 34, 41, 43, 85, 87, 99, 104, 105, 114, 115, 118, 124; Aug. 2, 1938, Aug. 13, 1939, (LR, MBM & BEM), species: 41, 43, 69, 87, 99, 105. Stream below Schlamm Lake, June 20, 1937, species: 48—1 ♂. State Forest—roads and open glades near water course with no flow of water, but occasional pools, June 20, 1937, species: 96; July 27, 29, and Aug. 2, 1938, species: 94 (10 ♂ 8 ♀, 7 ♂ 7 ♀ and 1 ♂ 1 ♀ respectively on the three dates), 99.

Clay. Creek and pond near Cloverland, Aug. 28, 1939, (Robert Trueman), species: 5, 22a, 25, 34, 41, 43, 99, 105. Near Jasonville, Aug. 19, 1938, species: 96.

Elkhart. St. Joseph River, west of Bristol, May 22, 1938, (AWT), species: 37, 60, 64; June 29, 1939 (EBM & BEM), species: 3, 15, 16, 18, 29.

Fountain. Pond about two miles south of Attica, June 21, 1940, species: 3, 20, 25, 37a, 43, 72, 99, 100, 104, 107. This pond appears to fill an excavation made by the removal of marl and seems quite deep; it is almost surrounded by wooded hills and is fed by springs.

Franklin. Old canal, seven miles west of Brookville, Oct. 6, 1940, species: 25, 29 (1 ♂ each).

Fulton. Stream near Rochester, June 29, 1939, species: 3, 43, 104.

Gibson. Stream in wooded hills near Foote's Lake, July 14, 1939, species: 3. Foote's Lake, July 14, 1939, species: 15, 25, 41, 43, 63, 69, 80, 87, 100, 103, 104, 105; Aug. 19, 1940, (considerable wind; following several cool days) species: 11, 15, 34, 43, 104; Aug. 21, 1938, species: 69, 85, 104, 105, 107, 115; Aug. 31, 1938, species: 15; Sept. 7, 1939, species: 11, 15, 25, 29, 34, 41, 43, 85. Old Lake at Oakland City, May 30, 1937, species: 34; July 12, 1939, species: 15, 22a, 34, 41, 43, 114, 119; Sept. 6, 1937, Sept. 6, 1939, species: 24, 25, 34, 41, 43, 99, 105, 107, 114, 118, 119. Water supply (new) lake at Oakland City, July 12, 1939, species: 15, 22a, 43, 44, 96, 99, 100, 105, 107, 114, 118, 119, 119a; Aug. 16, 1940, Aug. 20, 1938, species: 15, 22a, 25, 41, 43, 72, 99, 105, 107, 115, 118, 119; Sept. 6, 1939, species: 22a, 30, 41, 43, 99, 105, 118, 119. Pools, just east of Oakland City, July 12, 1939, species: 11, 41, 43, 72, 114, 115, 118; Aug. 14, 1937, Aug. 20, 1938, species: 41, 43, 99 105, 107, 118, 119; Sept. 6, 1937, Sept. 6, 1939, species: 11, 25, 41, 43, 98, 99, 100, 104, 105, 107, 108 (57 ♂ 8 ♀ and 1 ♂ 6 ♀, respectively), 114. Patoka River, below dam of Princeton water supply plant, Aug. 16, 1940, species: 15, 18, 29, 34, 59b—3 ♂, 99; Sept. 6, 1939, species: 15, 18, 29, 41, 82a—2 ♂, 85—1 ♂. Immediately below the dam is a small pool surrounded by sand bars; below this the river has high, bare clay banks.

Greene. Lakes in strip mines near Linton. A lake just south of Linton is located in a pit which has been abandoned for many years and the banks support a considerable growth of vegetation, including blackberries, willows, etc.; July 11, 1939, species: 11, 17, 20, 21, 22a, 41, 43, 87, 107, 115; Aug. 20, 1940, species: 15, 17, 20, 22a, 33, 34, 41, 43, 69, 99, 107. Lakes southwest of Linton are located in pits more recently abandoned and the banks support only scanty herbaceous vegetation, although there is a rather extensive area of cattails at one end of one of the pits; Aug. 22, 1940, species: 15, 17, 22, 22a, 25, 34, 41, 43, 44, 69, 72, 99, 104, 115, 118, 121. A dredged ditch led from one of the latter lakes; at the time of the visits the water was 12-30 inches deep, but had no current. Collecting was done along this stream through a pastured meadow and into the edge of a wooded area; Aug. 22-24, 1940, species: 4, 15, 17, 20, 22, 22a, 25, 41, 43, 72, 99, 100, 104, 107, 114, 115, 119, 121.

Hamilton. White River at Riverwood Dam, Aug. 24, 1939, (LR, MBM & BEM), species: 4, 15, 16; ripples about four miles above Noblesville, Aug. 24, 1939, (LR, MBM & BEM), species: 3, 15, 16, 29, 43, 52.

Huntington. Bog near Monument City, July 28, 1938, species: 45—1 ♂, 108—1 ♀.

Jackson. Pool formed by a dam in a small stream, forest nursery near Vallonia, June 13, 1938, species: 3, 20, 25, 34, 43, 99, 100, 115, 124.

Jasper. Much collecting in this county was done along ditches dug along roads or drainage ditches where crossed by roads; one mile north of Aix, June 26, 1940, species: 43, 66, 100, 117; nine miles north of Aix, June 26, 1940, species: 37a; eleven miles west of Monon, June 25, 1940, species: 21, 58, 100, 104. Wheat field, five miles north of Rensselaer, June 26, 1940, species: 49—teneral ♂. Carpenter Creek and adjacent marshy area in pasture, three miles northwest of Remington, June 25, 1940, species: 13, 16, 20, 29, 37; same creek flowing through a pasture, one mile northwest of Remington, July 10, 1940, species: 3, 4, 15, 16, 18, 20, 21, 29, 43.

Lagrange. Lake and wood lot, north of Lagrange, July 23, 1938, species: 79, 83, 112. Pigeon River, west of Howe, July 23, 1940, species: 16, 17, 29, 68, 75, 111, 112.

Laporte. Lake, two miles east of Laporte, July 22, 1938, species: 3, 7, 11, 13, 112. Pine Plantation, five miles north of Laporte, July 22, 1938, species: 105. Large pool in excavation (made in securing dirt for road building; with herbaceous vegetation and small shrubs just becoming well established on banks) and nearby pools in roadside ditches, July 2, 1940, species: 11, 13, 21, 22, 28, 29, 31, 43, 100, 111, 117, 118.

Marion. Riverside Fish Hatchery, Aug. 12, 1939 (LR, MBM & BEM), species: 17, 21, 22a, 25, 30, 34, 41, 43, 99, 105, 107, 114, 115, 118, 119, 124.

Marshall. Twin Lake, June 18, 1937 (AWT), species: 37—1 ♂.

Monroe. Morgan-Monroe State Forest, along roads near lakes and streams, July 14-15, 1937, species: 15, 20, 22a, 43.

Montgomery. Offield Creek, eight miles south of Crawfordsville, July 11, 1939, species: 3, 18, 20, 29.

Newton. Ditches near Kentland, June 17, 1939, species: 20, 21, 43, 99, 100; stream three miles east of Lake Village, June 26, 1940, species: 7, 20, 37a, 43, 72. Pools of stagnant water in cattail choked drainage ditch, June 27, 1940, species: 7, 13, 112. Iroquois River, near Kentland, June 26, 1940, (near dusk), species: 11, 13, 15, 18, 29, 43, 112.

Noble. Elkhart River, south of Albion, July 25, 1938, (AWT & BEM), species: 3, 4, 13, 17, 20, 29, 99, 112. Skinner Lake, July 25, 1938, (AWT & BEM), species: 11, 20, 21, 29, 33, 34, 35, 41, 43, 105. Collecting was confined to a short stretch of shore, partly bare and partly covered with dense herbage in the deep shade of trees.

Owen. Mill Creek near State Road 43—a large stream with clay banks, shaded at this point—Aug. 30, 1939, species: 4, 15, 43, 70.

Parke. Pond, one mile north of Rockville, June 19, 1940, 5:30-6:30 p. m., (JJF & BEM), species: 21, 29, 34, 43, 66, 87, 99; July 6, 1940, 4:00-4:45 p. m., species: 15, 21, 25, 29, 43, 66, 87, 99, 100, 104, 105, 107. Zygoptera were common on the earlier date, but rather rare on July 6; *Gomphus villosipes* was slightly more numerous in June than in July, but the libellulines were moderately rare in June and abundant in July.

Pike. Pools and fields in strip mine areas near Winslow, Aug. 14, 1937, species: 13, 22a, 72; Aug. 20, 1938, species: 121—11 ♂ 8 ♀

(this species was present in swarms, "hawking" over fields; specimens taken were all slightly teneral).

Pulaski. Small pools, surrounded by dense growth of sedges and grass, on either side of railroad, four miles south of Winamac, July 1 and 3, 1940, species: 7, 11, 13, 25, 43, 100, 104, 108—1 ♂ 1 ♀ (very teneral), 109 (pair flying tandem—♀ ovipositing), 112.

Ripley. Pond, with extensive beds of cattails, Batesville city park, Aug. 12, 1939, (LR & MBM), species: 20, 43, 99, 105, 115.

Rush. Flat Rock River at Rushville, Oct. 6, 1940, a few males of *H. americana* were the only Odonata seen.

Starke. Bass Lake, south shore—sand with growth of sedges, etc., July 2-3, 1940, late afternoon and early morning, cool and strong wind, species: 11, 21, 24, 25, 29, 43; Aug. 27, 1939, species: 41, 43, 111, 114. Robbins Ditch, six miles north of Knox, a large dredged ditch, banks well covered with herbaceous plants, July 1, 1940, species: 1, 3, 4, 29, 43, 58, 99, 104.

Steuben. Lake James in Pokagon State Park, July 7, 1940, (VAK), species: 16, 21, 24, 31, 43, 49—1 ♂ 1 ♀; July 25, 1938, species: 24; Aug. 17, 1937, (AWT), species: 114.

St. Joseph. Studebaker Proving Grounds, open field far from any water, Aug. 5, 1937 (AWT & BEM), species: 114—1 ♂ 2 ♀.

Sullivan. Sullivan-Greene State Forest, grass covered area near pools in old strip mine field, Aug. 19, 1938, species: 15, 17, 20, 22, 22a, 25, 99. In growth of cattails at edge of lake in Shakamak State Park, July 7, 1938, species: 20, 22, 44, 96, 99, 107, 115.

Tippecanoe. Hadley's Lake, Sept. 23, 1940, (BEH, RPM & BEM), species: 43, 110—2 ♂, 111—5 ♂, 112—20 ♂ 2 ♀; the water level was very low, and there were extensive areas of mud flats around the lake. Lafayette park, Aug. 1, 1939, species: 118, 122. Wabash River, five miles south of Lafayette, July 27, 1940, species: 55a—1 ♀, 59b—1 ♂. West shore of Wabash River, north of Lafayette, Sept. 2, 1939, species: 4, 5, 15, 16, 29, 43; Sept. 3, 1940, species: 4, 25, 29, 34, 43, 59b—♀; dragonflies, even *H. americana* were much more abundant in 1939 than in 1940; however, several gomphines were noted in 1940 and none in 1939. Pool in pasture along State Road 53 near White County, Aug 4, 1939, species: 13, 43, 100, 104. Cultivated fields and pasture along Little Pine Creek, June 23, 1939, following heavy rains, creek full of muddy water, species: 3, 15, 20, 21, 29, 104, 105, 107.

Union. Hannah Creek, just east of Liberty, Aug. 24, 1939, (LR, MBM & BEM), species: 3, 4, 17, 43, 70; Oct. 6, 1940, species: 5a—1 ♀, (no other Odonata seen). This is a rock-bottom creek with heavy growth of sedges, shrubs and trees on the bank; in August, 1939, the water was two to six inches deep with noticeable current, in 1940, most of the creek bed was dry with occasional pools of water.

Vanderburgh. Small drainage ditch, with only pools of water, near Stacer, July 13, 1939, species: 20, 41, 43, 100, 104.

Vigo. Pond at Pimento, Aug. 21, 1940, species: 11, 15, 20, 21, 22, 25, 43, 44, 99, 100, 104, 105, 115, 118. Pond, four miles south of Pimento, Aug. 21, 1940, species: 11, 15, 43, 99, 105. Odonate life was much less abundant both in individuals and species at the latter pond, although at many times in the past it has been found to have an abundance of dragonflies.

Warren. Wabash River, opposite Covington, June 20-21, 1940, (5:00-6:00 p.m., each day), species: 15, 29, 52a—22 ♂ 26 ♀, 55a—2 ♂ 2 ♀, 59a—1 ♀, 59b—8 ♂ 7 ♂ (all very teneral), 64—15 ♂ 6 ♀; July 6, 1940, (12:30-1:00 p.m.), species: 52a—1 ♀, 55a—2 ♂ 1 ♀, 59b—1 ♀ (teneral), 112—1 ♂. Collecting was done in a grove of trees with a dense undergrowth of weeds and grass in which there were, however, several roads, paths and trampled areas, on the bank high above the water. *G. amnicola* has always been considered a rare species, except by Wilson (1909) whose references to its abundance have been questioned by other students of the Odonata. However, no other collector since Walsh appears to have spent much time along the larger streams of the upper Mississippi system and it appears probable that collecting along these rivers at the proper season might yield large numbers of several of the so-called rare species of Gomphus.

Warrick. Water supply lake, Booneville, May 30, 1937, species: 22a, 34, 43, 55, 104, 107, 118. Ohio River, several places near Newburgh, July 13, 1939, in extensive collecting the only species found was *A. apicalis* which seemed to be present everywhere along the river and was quite abundant on the bare ground and the iron and concrete structural works of a navigation dam.

Wayne. Elkhorn Creek, a rock bottom creek, several miles south of Richmond, Oct. 6, 1940, species: 4, 70, 114.

Wells. Vanemon Swamp, July 11, 1940 (5:00-6:00 p.m.), species: 7—1 ♂, 8—1 ♂, 9—68 ♂ 11 ♀, 11—8 ♂ 24 ♀, 12—29 ♂ 7 ♀, 13—5 ♂, 43, 112, 115, 117.

White. A number of streams crossed by State Road 53, most of them dredged ditches flowing through pastures, were visited in 1939; however, the banks of these streams were covered with herabaceous plant growth and the stream beds had not been trampled or disturbed in most places; Little Monon Creek (also called Hoagland Ditch), June 17 and 23, species: 1, 3, 18, 20, 21, 27, 29, 41, 43, 58, 93, 100, 107, 117; Aug. 4, species: 3, 4, 13, 15, 16, 17, 18, 20, 21, 29, 43, 70, 99, 100, 121; Big Creek, June 17 and 23, species: 3, 20, 21, 22a, 27, 43, 104, 117; Big Pine Creek, June 23, species: 20, 21, 22a, 58, 100. Lake Freeman near Monticello, June 22 and July 20, 1938, species: 112; near Oakdale Dam, Sept. 15, 1940 (LR, BEH & BEM), species: 22a, 25, 29, 34, 43.

List of Species Recorded From Indiana, With Notes on 1937-1940 Collections

1. *Calopteryx aequabilis* Say. *Starke, *White.
2. *C. angustipennis* (Selys).

3. *C. maculata* (Beauvois). Allen, *Carroll, Elkhart, Fountain, Fulton, *Hamilton, Jackson, Jasper, Laporte, Montgomery, Noble, Posey, *Starke, Tippecanoe, Union, *White.

4. *Hetaerina americana* (Fabricius). *Carroll, *Greene, Hamilton, Jasper, Noble, *Owen, Rush, *Starke, Tippecanoe, Union, Wayne, White.

5. *H. titia* (Drury). *Carroll, *Clay, Tippecanoe.

*5a. **Archilestes grandis* (Rambur). *Union. Since this species was found at Oxford, Ohio, September 25, 1927, by the late E. B. Williamson, and in the vicinity of Dayton a year or two later by Charles W. Cotterman (Williamson, Cotterman, 1931, repeated attempts have been made to find it in the adjacent parts of Indiana. However, no Indiana record for it was obtained until October 6, 1940, when one female was captured along Hannah Creek, about one mile east of Liberty, and about 12 miles northwest of Oxford. This was the only dragonfly seen during a thorough search of about one-half mile of the creek in the early afternoon; it was captured as it alighted on a reed. Two males of the species were taken at Oxford earlier in the day. They were found along a rocky creek bed with only occasional pools of water in a shaded ravine. Before their capture they were noted to fly over these pools of water, "hawking" in the manner of aeshnines.

6. *Lestes congener* Hagen.

7. *L. disjunctus* Selys. Laporte, Newton, Pulaski, Wells. In the past *L. disjunctus* and *L. forcipatus* have been rather badly confused and previously published records of these species for Indiana (and elsewhere) should be disregarded. Mrs. L. K. Gloyd and the author have reexamined all specimens of these species in the Williamson Collection and in their own collections during the last few years and it is expected that additional material will be studied and that notes on the distribution of these species can be published soon. The criteria which have been used for separating these species in the past, the presence *(disjunctus)* or absence *(forcipatus)* of a sooty black stripe on the metapleural suture and the relative length of the basal tooth of the superior appendage in comparison with the apical tooth (longer in *forcipatus*, equal or shorter in *disjunctus)*, appear to be of no value. Mrs. Gloyd and the author have developed the following keys for distinguishing the two species; identification of the females is definite and rather easy, that of the males is more difficult and sometimes can be accomplished only by a study of the structure of the penes.

Males:

Distance from the base of the basal tooth of the superior appendages to the base of the apical one equal to or less than the distance from the base of the latter to the tip of the appendage; width across top of V-shaped incision in caudal margin of segment 10 one-third or less of the width of the segment if abdomen has not been crushed or distorted; greatest width of shield-shaped cavity in ventral surface of vesicle near center or in apical (caudal) half; sides of apical portion of penis sub-parallel in ventral view, apical margin straight or concave .... *disjunctus*

Distance from the base of the basal tooth of the superior appendages to the base of the apical one greater than the distance from the latter to the tip of the appendage; width across top of V-shaped incision in margin of segment 10 more than one-third of the width of the segment if abdomen is not distorted; greatest

width of the shield-shaped cavity in the ventral surface of the vesicle near base (cephalic end); apical portion of penis distinctly pear-shaped in ventral view, apical margin convex .... *forcipatus*

Females:

Ovipositor not extending beyond the tip of the abdomen; rear of head dark .... *disjunctus*

Ovipositor extending beyond the tip of the abdomen; rear of head light .... *forcipatus*

8. *L. eurinus* Say. Wells.

9. *L. forcipatus* Rambur. Wells. Although *forcipatus* appears to be much less common and more local in distribution than *disjunctus* it is well established at Vanemon Swamp as may be seen from the 1940 collection which contained 68 ♂ ♂ and 11 ♀ ♀ of *forcipatus* and only one ♂ of *disjunctus*. A long series of *forcipatus* was secured here on July 4, 1926, also.

10. *L. inaequalis* Walsh.

11. *L. rectangularis* Say. *Carroll, Gibson, *Greene, *Laporte, *Newton, Noble, *Pulaski, *Starke, Vigo, Wells.

12. *L. dryas* Kirby. Wells. This species has long been known as *uncatus* in this country; although many authorities recognized the specific identity of the American and the Old World forms and Schmidt called attention to this identity in 1930, authors continued to use both names until Cowley suppressed the name *uncatus* in 1935 after a careful study of numerous specimens from both continents.

13. *L. unguiculatus* Hagen. *Jasper, *Laporte, *Newton, Noble, *Pike, *Pulaski, *Tippecanoe, Wells, *White.

14. *L. vigilax* Hagen.

15. *Argia apicalis* (Say). Carroll, Clark, Elkhart, Gibson, *Greene, Hamilton, *Jasper, *Monroe, *Newton, *Owen, Parke, Sullivan, Tippecanoe, Vigo, Warren, *Warrick, White.

16. *A. moesta* (Hagen). *Carroll, Elkhart, Hamilton, *Jasper, Lagrange, Steuben, Tippecanoe, *White.

17. *A sedula* (Hagen). Boone, *Carroll, *Clark, *Greene, Lagrange, *Marion, Noble, *Sullivan, Union, White.

18. *A. tibialis* (Rambur). *Elkhart, Gibson, *Jasper, *Montgomery, *Newton, Tippecanoe, White.

19. *A. translata* Hagen.

20. *A. violacea* (Hagen). Boone, Clark, *Fountain, Greene, *Jackson, Jasper, Monroe, *Montgomery, Newton, Noble, *Ripley, *Sullivan, Tippecanoe, *Vanderburgh, Vigo, White.

21. *Enallagma antennatum* (Say). Boone, *Clark, *Greene, Jasper, *Laporte, Marion, Newton, Noble, Parke, *Starke, Steuben, Tippecanoe, Vigo, *White.

22. *E. aspersum* (Hagen). Clark, *Greene, *Laporte, *Sullivan, *Vigo.

22a. *E. basidens* Calvert. (Montgomery, 1932). *Boone, *Carroll, *Clark, *Clay, Gibson, Greene, *Marion, *Monroe, *Pike, *Sullivan, Warrick. The specimens from Clark County (Francke Lake) are considerable larger than usual for this species. Measurements of a male from this

series were: length 27.5 mm., abdomen 22 mm., rear wing 14.5 mm.; of a female: length 26.5 mm., abdomen 21 mm., rear wing 15 mm. Specimens from the Green County Collection were found to have the following measurements: ♂, length 23 mm., abdomen 18 mm., rear wing 11 mm.; ♀, length 23.5 mm., abdomen 18.5 mm, rear wing 12 mm.

23. *E. boreale* Selys.

24. *E. carunculatum* Morse. Carroll, Gibson, *Starke, Steuben.

25. *E. civile* (Hagen). Carroll, Clark, Clay, *Fountain, *Franklin, Gibson, Greene, *Jackson, Marion, *Morgan, Parke, *Pulaski, *Starke, *Sullivan, Tippecanoe, Vigo, White.

26. *E. cyathigerum* (Charpentier).

27. *E. divagans* Selys. White.

28. *E. ebrium* (Hagen). *Laporte.

29. *E. exsulans* (Hagen). Boone, Carroll, Elkhart, *Franklin, Gibson, Hamilton, Jasper, Lagrange, *Laporte, Montgomery, Newton, Noble, *Parke, *Starke, Tippecanoe, *Warren, White. A female of this species was taken from a spider web along Little Monon Creek on Aug. 4, 1939. When discovered it was as still as if dead, but when an attempt was made to secure it the web was broken and the dragonfly tried to flutter away. However, it could not fly and when captured was found to have the body completely severed near the caudal margin of the fourth abdominal segment except for a very thin strip of the venter.

30. *E. geminatum* Kellicott. Gibson, Marion.

31. *E. hageni* (Walsh). *Laporte, Steuben.

32. *E. piscinarium* Williamson.

33. *E. vesperum* Calvert. *Clark, *Greene, Noble. The specimens from Francke Lake and the lake near Linton were collected from above the water at dusk, but those at Skinner Lake were taken from shaded vegetation in mid-afternoon.

34. *E. signatum* (Hagen). Carroll, *Clark, *Clay, Gibson, *Greene, *Jackson, *Marion, Noble, *Parke, *Tippecanoe, Warrick, White.

35. *E. traviatum* Selys.

36. *Nehalennia gracilis* Morse.

37. *N. irene* Hagen. Elkhart, *Jasper, Marshall.

37a. *Amphiagrion abbreviatum* (Selys). (Montgomery, 1937). *Fountain, Jasper, *Newton.

38. *A. saucium* (Burmeister).

39. *Chromagrion conditum* (Hagen).

40. *Ischnura kellicotti* Williamson.

41. *I. posita* (Hagen). *Carroll, Clark, Clay, Gibson, *Greene, Marion, Noble, *Starke, Vanderburgh, White.

42. *I. prognata* (Hagen).

43. *I. verticalis* (Say). Adams, Boone, Carroll, Clark, Clay, Fountain, Gibson, Greene, Hamilton, Jackson, Jasper, *Laporte, *Marion, Noble, *Newton, *Owen, Parke, Pulaski, *Ripley, *Starke, Steuben, Tippecanoe, Union, Vanderburgh, Vigo, Warrick, Wells, White. Flower heads of milkweed and over plants, abundant along Little Monon Creek on Aug. 4, 1939, attracted many Hymenoptera and Diptera, especially a small black fly which had clustered on some flowers until they were

almost covered. Dragonflies, especially *I. verticalis*, were noted to hover near these flowers, as if hunting for prey. A female *verticalis* was watched as it flew about the umbels of a milkweed until it caught one of the small flies. It flew directly at the fly, siezed it with its feet, then started flying directly backwards (reversing its motion completely without turning its body at all). Both dragonfly and fly were captured and the latter was determined by C. T. Greene as *Empis clausa* Coq.

44. *Anomalagrion hastatum* (Say). Clark, Gibson, *Sullivan, Vigo.

45. *Tachopteryx thoreyi* (Hagen). Huntington.

46. *Cordulegaster diastatops* (Selys).

47. *C. maculatus* Selys.

48. *C. obliquus* (Say). Clark.

49. *Progomphus obscurus* (Rambur). Jasper, Steuben.

50. *Hagenius brevistylus* Selys.

51. *Ophiogomphus rupinsulensis* (Walsh).

52. *Erpetogomphus designatus* Hagen. *Carroll, Hamilton.

52a. *Gomphus amnicola* Walsh. (Montgomery, 1925). *Warren. Many of the specimens obtained on June 20 and 21 were somewhat teneral and all of them were comparatively freshly emerged, but the female taken on July 6 appeared quite old. The color pattern is much clearer in younger specimens.

52b. *G. cornutus* Tough. (Montgomery, 1934).

53. *G. crassus* Hagen.

54. *G. lineatifrons* Calvert.

55. *G. exilis* Selys. *Warrick.

55a. *G. externus* Hagen. (Montgomery, 1930). *Tippecanoe, *Warren.

56. *G. fraternus* (Say).

57. *G. furcifer* Hagen.

58. *G. graslinellus* Walsh. Allen, *Jasper, *Starke, *White.

58a. *G. laurae* (Williamson). (Williamson, 1932.)

59. *G. lividus* Selys.

59a. *G. notatus* Rambur. (Montgomery, 1925). *Warren.

59b. *G. plagiatus* Selys. (Montgomery, 1925). Gibson, *Tippecanoe, *Warren. The specimens from the Wabash River in Warren County were taken at very early dates for this species (June 20 and 21 and July 6). However, all of them were very teneral.

60. *G. quadricolor* Walsh. Elkhart.

61. *G. spicatus* Hagen.

62. *G. spiniceps* (Walsh). *Carroll.

62a. *G. subapicalis* Williamson. (Montgomery, 1934.)

63. *G. submedianus* Williamson. Gibson.

64. *G. vastus* Walsh. Elkhart, *Warren.

65. *G. ventricosus* Walsh.

66. *G. villosipes* Selys. Jasper, Parke. This species was rather common at the Parke County pond on both dates (June 19 and July 6) although much more numerous on the earlier date. Females were ovipositing by tapping the abdomen against the algal mat on the surface of the water near the shore. Males as well as females frequently

alighted on this mat. There were also algal mats on the water at the Jasper County locality.

66a. *G. viridifrons* Hine. (Williamson, 1920.)

67. *G. williamsoni* Muttkowski.

68. *Dromogomphus spinosus* Selys. *Carroll, Lagrange.

69. *D. spoliatus* (Hagen). *Clark, Gibson, *Greene.

70. *Boyeria vinosa* (Say). *Carroll, Wayne, *White.

71. *Basiaeschna janata* (Say).

72. *Anax junius* (Drury). Fountain, Gibson, *Greene, *Newton, *Pike.

72a. *A. longipes* Hagen. (Montgomery, 1937.)

73. *Aeshna canadensis* Walker.

74. *A. clepsydra* Say.

75. *A. constricta* Say. Lagrange.

76. *A. mutata* Hagen.

77. *A. tuberculifera* Walker.

78. *A. umbrosa* Walker. Cass.

79. *A. verticalis* Hagen. Lagrange.

80. *Nasiaeschna pentacantha* (Rambur). Gibson.

81. *Epiaeschna heros* (Fabricius).

82. *Didymops transversa* (Say). *Clark.

*82a. **Macromia georgina* (Selys). *Gibson. The addition of this species to the state list is based upon two males collected along the Patoka River, September 6, 1939, and two males collected at Foote's Lake, July 18, 1931. These four specimens agree rather well with Williamson's description of the species (1908), except that two of them have the antehumeral stripe shorter than described. However, a careful study of the North American species of this genus is much needed and final classification of individual specimens, especially in the *illinoiensis-georgina* group, must await such monographic work. *Georgina* has been recorded previously from North and South Carolina, Florida, Georgia and Texas, and *australensis*, which Walker has considered as a synonym, from Maryland, Alabama, Oklahoma and Texas.

83. *M. illinoiensis* Walsh. Lagrange.

84. *M. pacifica* Hagen.

85. *M. taeniolata* Rambur. *Clark, Gibson.

86. *M. wabashensis* Williamson.

87. *Epicordulia princeps* (Hagen). Carroll, Clark, *Parke.

88. *Neurocordulia obsoleta* (Say).

89. *Tetragoneuria cynosura* (Say). Clark.

90. *T. cynosura simulans* Muttkowski. *Clark.

91. *T. spinigera* Selys.

92. *Dorocordulia libera* (Selys).

93. *Somatochlora ensigera* Martin. *White. The two specimens from Little Monon Creek are quite teneral, indicating that they had probably emerged only recently and had spent their immature life in this creek. This creek in open prairie is a very different habitat from the woodland streams from which this species has been previously collected.

94. *S. linearis* (Hagen). Clark, *Morgan.

95. *S. tenebrosa* (Say).

96. *Libellula cyanea* Fabricius. *Carroll, Clark, *Clay, Gibson, *Sullivan.

97. *L. julia* Uhler.

98. *L. incesta* Hagen. Gibson.

99. *L. luctuosa* Burmeister. Carroll, Clark, *Clay, *Fountain, Gibson, Greene, *Jackson, Marion, Noble, Parke, *Ripley, *Starke, *Sullivan, Vigo, White.

100. *L. pulchella* Drury. Clark, *Fountain, Gibson, Greene, *Jackson, Jasper, *Laporte, Pulaski, Vanderburgh, Vigo, *White.

101. *L. quadrimaculata* Linné.

102. *L. semifasciata* Burmeister.

103. *L. vibrans* Fabricius. *Gibson.

104. *Plathemis lydia* (Drury). Allen, Carroll, Clark, Fountain, Gibson, Greene, Jasper, Parke, Pulaski, *Starke, Vanderburgh, Vigo, *Warrick, *White.

105. *Perithemis tenera* (Say). Clark, Clay, Gibson, *Laporte, *Marion, Noble, Parke, *Ripley, Vigo.

106. *Nannothemis bella* (Uhler).

106a. *Erythrodiplax minuscula* (Rambur). (Montgomery, 1930.)

106b. *E. umbrata* (Linné). (Montgomery, 1935.)

107. *Erythemis simplicicollis* (Say). Carroll, Clark, *Fountain, Gibson, Greene, Marion, *Sullivan, Tippecanoe, Warrick, White.

108. *Sympetrum ambiguum* (Rambur). Gibson, *Huntington, *Pulaski.

109. *S. corruptum* (Hagen). *Pulaski.

110. *S. decisum* (Hagen). *Tippecanoe.

111. *S. obtrusum* (Hagen). Lagrange, *Laporte, *Starke, Tippecanoe.

112. *S. rubicundulum* (Say). Allen, Fayette, Lagrange, *Laporte, *Newton, Noble, *Pulaski, Tippecanoe, *Warren, Wells, White. Several of the specimens from the 1940 collections show tendencies towards the clouded wing form which is regarded as a separate species, *assimulatum*, by some authorities. The two females from the Iroquois River (Newton Co.) have the wings distinctly colored; in one this is quite marked to the nodus, especially along the costa, in the other it is rather faint beyond the second or third antenodal cross vein, although there is a faint tinge to the nodus. Three specimens (2 ♂ 1 ♀) from Hadley's Lake (Tippecanoe Co.) have the wings colored to the nodus and three others (2 ♂ 1 ♀) have the wings distinctly colored to the level of the triangles and tinged to the nodus. Of the three mated pairs taken here, neither male or female of one had clouded wings, one male with wings clouded to the nodus was mated to a female with partly colored wings, and the female with the wings colored to the nodus was mated to a male with uncolored wings.

113. *S. semicinctum* (Say).

114. *S. vicinum* (Hagen). *Allen, *Clark, Gibson, Greene, *Marion, *Starke, Steuben, St. Joseph, *Wayne.

115. *Pachydiplax longipennis* (Burmeister). Carroll, Clark, Gibson, *Greene, *Jackson, Marion, *Ripley, *Sullivan, Vigo, Wells. A female captured at Francke Lake, June 16, 1938, was held by the wings until a mass of eggs extruded, then dipped to the water. The mass of eggs sank three or four inches, then separated. The process was repeated several times; the egg mass almost always divided, but only once or twice was this violent enough to be called an "explosion." Even in these cases the masses always sank deeper and dissolved with less violence than the explosion of the egg masses of *Perithemis tenera* which has been described elsewhere. Usually the mass merely fell apart.

116. *Leucorrhinia frigida* Hagen.

117. *L. intacta* (Hagen). *Clay, *Jasper, *Laporte, Wells, *White.

118. *Celithemis elisa* (Hagen). Clark, Gibson, *Greene, *Laporte, *Marion, Tippecanoe, *Vigo, Warrick.

119. *C. eponina* (Drury). Gibson, *Greene, *Marion, *Ripley.

119a. *C. fasciata* Kirby. (Montgomery, 1937.) Gibson. Although only one specimen was taken a number were seen, showing that this species has become established at the Oakland City lake where one specimen was obtained in 1936. The specimen (♂) obtained agrees with the characters of *fasciata* except for the pale basal enclosed area.

120. *C. monomelaena* Williamson.

121. *Pantala flavescens* (Fabricius). *Greene, *Pike.

122. *P. hymenaea* (Say). *Tippecanoe.

123. *Tramea carolina* (Linné).

124. *T. lacerata* Hagen. Clark, *Jackson, Marion.

125. *T. onusta* Hagen.

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The Effect of Temperature Upon the Development of Cockroaches

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In centuries past the ancestors of modern cockroaches lived in forests of tropical and semi-tropical regions. Gradually roaches have migrated to other areas and now are established in most tropical and temperate regions of the world. Food of those ancient forms consisted of vegetation and other organic matter, but in comparatively modern times certain species have found the environment and food of human habitations suitable for their existence. Man has carried these species through commerce to many countries until now some of them are household pests throughout most of the world. The limitations on the spread of these former inhabitants of the tropics are several in number, but the temperature factor is perhaps the most important in the distribution and development of the various species.

Several years ago a study was initiated on the biology of six species of roaches found in homes in Indiana. The six species involved are the American cockroach *(Periplaneta americana* Linn.), the Oriental cockroach *(Blatta orientalis* Linn.), the German cockroach *(Blattella germanica* Linn.), the brown-banded roach *(Supella supellectilium* Serv.), the Pennsylvania woods-roach *(Parcoblatta pennsylvanica* DeGeer), and the smoky brown cockroach *(Periplaneta fuliginosa* Serv.). In a recent publication Gould and Deay* have presented the information obtained in the study of the biology of the six species and included some data on the effect of temperature upon their development. This paper gives additional data on the temperature-development relationship and summarizes this information on all six species.

The most interesting species in regard to the effects of temperature is the brown-banded roach, an insect that in the past twelve or thirteen years has appeared and become established as a household pest in the United States. Previous to this a few records had been published on this roach from France, Africa and Australia. At the present time it is established in at least twenty states and thrives in heated homes, apartments and hospitals. Apparently the temperature requirements of this species has confined the colonies to buildings where moderately high temperatures are maintained. Undoubtedly individuals have attempted to establish colonies in other buildings, but winter conditions have killed off or forced the colony to move to warmer locations. Such a temperatory condition probably existed in a tourist cabin in Hiawatha, Kansas, where a single mature female was captured in September of 1940. This individual probably was transported in luggage by tourists from some southern city and could not possibly have continued to exist in this unheated cabin during the winter.

* Purdue University Agricultural Experiment Station Bulletin 451, 1940.

The brown-banded roach is not confined to any particular room in the house but does frequent such high locations as clothes closets, furniture and the backs of pictures. These locations have a higher temperature than hiding places in basements and behind baseboards that are frequented by other species. The habit of hiding themselves or depositing egg capsules in furniture and luggage probably accounts for the rapid spread of this insect in both southern and northern cities.

TABLE I.—The Average Duration of the Incubation Period of the Brown-Banded Cockroach at Four Temperature Levels.

	Location of Capsules				Total or Average
	Room	Shelf 1	Shelf 2	Shelf 3	
Number of capsules.........	425	200	500	100	1,225
Average temperature	76.8	78.9	80.8	85.9	79.7
Average incubation	73.8	57.2	43.1	36.9	57.6
Regression coefficient	6.7	...	3.4	...	5.1

The effect of temperature upon the duration of the incubation period has been studied over a period of 39 months. Capsules were removed upon deposition from rearing jars and placed either singly or in small groups in salve boxes. These boxes at first were placed on a table in the laboratory where the room temperature varied as much as 20 degrees daily and from 70° F. in spring and fall to over 90° F. in winter and summer. Later capsules were placed on different shelves in the constant temperature chamber where the temperature variation on each shelf was seldom more than five degrees. In addition the humidity in this chamber was kept at a more or less constant level of 65 per cent.

The results of these observations are shown in the accompanying table. The term regression coefficient indicates that within the limits of the values used the duration of the incubation period was shortened a calculated number of days for each degree rise in temperature. In the case of capsules kept on the top and third shelf of the chamber this figure was inconclusive, while under room conditions the period was shortened 6.7 days for each degree rise in temperature, on the second shelf 3.4 days and for all conditions 5.1 days. These results have a practical application in that they may aid the exterminator in predicting the proper time for a second application which would kill all young hatching from capsules produced before the first treatment. In other words, if the average temperature is 75° F., the capsules would hatch in 80 days or the second application should be made about three months after the first.

Temperature also had a decided influence upon the growth of the nymphs. The 147 individuals reared under room conditions where the average temperature was 76.9° F. required 164 days for development from hatching to maturity. In the constant temperature chamber where the average temperature was about 84° F. only 92 days were necessary on the average for the 240 nymphs to mature. The regression coefficient

between the length of nymphal development and temperature indicates that for each degree rise in temperature the developmental period was shortened 11 days.

This relationship between temperature and development offers an explanation of the rapid increase of roach populations in homes. As stated before, the brown-banded roach is of tropical origin and is found in the warmer locations of the house. In heated homes the temperature of the places frequented by this roach probably averages around 80° F. most of the year. At this temperature incubation would require 50 days and nymphal development 125 days, which indicates a possibility of two generations a year. Of course during the spring and fall homes are not heated and temperatures may be below the optimum for development, but at other times temperatures may be above the 80° mark. Suppose that a single capsule was brought into this home in luggage. According to figures previously published 13.2 nymphs should hatch from this capsule. If all individuals lived and half were females producing six capsules each, a possible population of 515 roaches would be in this house at the end of one year or 806,000 at the end of two years.

The higher temperatures also affected the adult stage. Reproduction was speeded up and longevity was greatly reduced at the higher temperature. Under room conditions females lived 206 days and in the constant temperature chamber 125 days. Excessively high temperatures existing at times on one shelf of the constant temperature chamber reduced egg production with a higher percentage of infertility and in some instances caused the death of adults and nymphs.

The American cockroach is one of the three common household species that has become acclimated to domestic life and thrives throughout the temperate zone of the world. In the southern states this species is found both in buildings and out-of-doors where it lives during most of the year under the bark of trees, in rubbish piles and other similar locations. In the North this roach may wander away from buildings and infest garbage dumps and trees during July and August, but for the most part its activities are confined to buildings where food is prepared, served or stored. The adults and nymphs prefer to congregate in dark damp locations where the temperature is about 82° F. However, they differ from the brown-banded roach in that they are active and continue normal functions at temperatures around 70° F. Under conditions found in buildings the American roach ranges over most of the basement and first floor, and even higher if food is available. For deposition of egg-capsules and congregating with other roaches, places near heat and water pipes are sought. The so-called "nests" mentioned by pest control operators are areas that roaches find favorable from the standpoint of temperature, humidity, darkness and nearness of food. Such areas are soon stained by the roaches and have a characteristic roachy odor. A "nest" of roaches was observed on a bare wall of a meat packing establishment. Apparently the roaches had congregated here while the temperature was high. At the time of collection the roaches were thoroughly numbed by the 50° temperature.

In the study of the American roach 988 capsules have been incubated at three temperature levels during a period of 77 months. Under room conditions the eggs hatched in an average of 58.5 days at an average temperature of 75.7° F., while on one shelf of the constant temperature chamber capsules hatched in an average of 48 days at 78.8° and on another shelf 34.5 days at 84.5°. The range of incubation of all capsules showed that at an average temperature of 70° F., 84.3 days were required by incubation and at 85.8° F. only 32.7 days. The gain per degree rise in temperature showed a shortening of the incubation period by 2.8 days. On the few occasions when temperatures of 88° or higher were maintained for any period of time, many of the capsules failed to hatch.

The duration of the nymphal developmental period for this species was more influenced by temperature than for any of the other species studied. Under room conditions where temperatures fluctuated around 76° F., 520 days were necessary on the average for development, while in the constant temperature chamber with an average of 83° F. only 195 days were necessary. Although the higher temperatures accelerated growth, it also speeded up the various life processes and caused an earlier death of adults. Under room conditions the females lived on an average 441 days and produced 57.6 capsules of which 32.6 were fertile. In the constant temperature chamber females lived 371 days and produced 47 capsules of which 28.2 were fertile.

The responses of the Oriental roach to temperature variations were similar to those of the American roach. This species was usually confined to the basement and first floor of business buildings, but in some instances colonized around heat and water pipes on higher floors where access to such locations was made easy by incinerators and plumbing. During the summer months colonies dispersed throughout the building and often spread to nearby dumps and garbage piles. One such infestation was observed in South Bend in the summer of 1938 when residents complained of this roach migrating from the city dump to their nearby homes. Apparently this dump was continuously inhabited by roaches as fishermen went there to collect them for fish bait. During the hot summer months colonies of roaches were found around foundations and back porches of homes, especially if the garbage pail was nearby. The common source of infestations in homes was by migrations through sewer and drainage pipes.

The duration of the incubation period fluctuated with the temperature similar to the responses of the American roach. The average incubation period was 57 days at an average temperature of 78° F. and 37 days at a temperature of about 85° F. In analyzing the regression between the duration of incubation of the 56 capsules and the temperatures at which they were kept, it was found that the incubation period was shortened 2.6 days for each degree rise in temperature.

The nymphal developmental period varied considerably even with roaches reared together in the same container. Some nymphs matured in about a year, while some required an additional year. Under room conditions the average length of the nymphal stages was 533 days, while in the constant temperature chamber it was 316 days.

Although the Oriental roach lived throughout most of the year in heated buildings, this species still showed an indication of a seasonal cycle. Adults both in rearing jars and in nature appeared in the spring months and died in the late summer or fall. Nymphs in many instances required nearly two years for development and yet they never matured except in the spring months. Adults living only during the summer months also influenced egg production and incubation.

The third common household species is the German roach. This pest is well established in homes throughout the world and is found in buildings where food is prepared, served or stored. Under favorable conditions of food and temperature this little species is able to pass through a complete cycle in about 100 days and accordingly can soon become numerous about an infested premise. In our studies capsules hatched in 28 days at a temperature of 76° F. and in 17 days at an average temperature of 85° F. At exceedingly high temperatures the duration of the incubation period was still shorter but the percentage of infertility was considerably higher. Under natural conditions the capsules of this species are probably exposed more to a favorable temperature than are other species, for this is the only instance among home-inhabiting forms that the female carries the capsule during incubation. The regression coefficient, in our studies, between duration of incubation and temperature showed that for each degree rise in temperature the incubation period was shortened 1.6 days.

Nymphs reared at an average room temperature of 76° F. required 135 days for development, while at 85° F. only 74 days were necessary. Adult roaches confined at the higher temperature lived 145 days as against 232 days for those at room temperature and, as might be expected, they produced fewer capsules.

Of the various species studied the woods-roach showed the least response to temperature fluctuations, for in its natural habitat under the bark of trees, nymphs remain active throughout the year. Young nymphs exposed to freezing temperatures in mid-winter were still active and able to scurry for shelter. In the spring and early summer months these nymphs matured. Flights of winged males were observed in May and June. Homes in or near wooded areas were frequently infested with males or by the crawling females or nymphs. This invasion of homes by this species was more by accident than by design, as they do not breed in homes.

Under natural conditions the woods-roach has a definite seasonal cycle with one generation a year. Adults appear in early summer and produce egg capsules during the summer months. In captivity they had the same cycle except that certain individuals required two years to complete development. Egg capsules which were present in summer and fall months only had an incubation temperature of 81° F. and hatched in 34 days. At the high temperature of 85° F. in the constant temperature chamber few of the capsules hatched. Conditions in this chamber also had an adverse effect upon nymphal development, as only two matured and they required over a year.

TABLE II.—Summary of the life cycle of the Common Cockroaches Reared at Two Temperature Levels.

Roach	Temperature Range*	Length of Adult Life in Days	Number of Capsules Per Female	Number of Nymphs Hatching Per Capsule	Duration of Incubation Period in Days	Number of Days for Nymphal Development
American	Room	441	58	13	58	520
	High	371	47	15	41	225
Oriental	Room	110	9	13	62	533
	High	100	6	8	45	316
German	Room	232	5	32	28	135
	High	145	5	27	20	95
Brown-banded	Room	206	13	13	74	174
	High	150	12	13	42	125
Smoky brown	Room	250	17	18	59	344
	High	...	...	...	43	405**
Woods	Room	150	..	...	...	284
	High	...	20	26	34	383

* Temperatures under room conditions varied from 69 to 90° F. and are used in this table as an average of 76° F. Temperatures used in the high column were obtained in the constant temperature chamber where the range was from 78 to 88° F. Figures in the high column are calculated on an average of 81° F. The adults of the woods roach were present in the summer months.

** Based on a few records where average temperatures were about 85° F.

The smoky brown roach, a native of the southern United States, has been found on a few occasions in heated buildings in the North. This species is closely related to the American roach and like it responded to temperature ranges to the same degree. In a greenhouse this roach has undergone a continuous development for the past five years. It exhibited no tendency for a seasonal cycle as adults were present throughout the year.

Egg capsules, which were kept under room conditions, hatched in 70 days at an average temperature of 73° F., 60 days at 75° F., 56 days at 78° F., and 43 days at 81° F. The average of all capsules kept under room conditions showed that incubation required 58 days at 75.7° F. In the constant temperature chamber incubation required an average of 37 days at 85° F. Nymphal development under room temperatures varying between 72 and 81° F. required 274 to 439 days with an average of 344. The growth rate of this species was not accelerated by the higher temperatures in the constant temperature chamber, as 405 days were required for development at an average temperature of 85° F.

Summary. The three common species of roaches infesting buildings, the German roach, the American roach, and the Oriental roach, showed a decided similarity in the temperature requirements for development. The temperature range from 74 to 83° F. was the most favorable for incubation and nymphal development. The brown-banded roach required higher temperatures for normal development, while the woodsroach responded to lower temperatures. Acceleration of development of all species continued up to 84° F. and in some cases even higher, although higher temperatures were detrimental to capsule production and shortened the lives of adults.

A Crystal Violet-Eosin Combination Stain for General Histology

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This is essentially a modification of Gram's procedure securing both stain and counterstain in the same operation by employing a combination staining solution. The stain consists of two solutions which are never mixed.

A. Staining solution.[1]

Eosin Y, saturated solution in absolute alcohol	4 cc.
Crystal violet, saturated solution in absolute alcohol	4 cc.
Xylol	14 cc.
Absolute alcohol	6 cc.

B. Mordant.

Iodine, saturated solution in xylol	1 part
Xylol	35 parts

The staining solution should be made up frequently in small amounts since the evaporation of the alcohol will cause it to precipitate, covering the sections with crystals which are hard to remove. For this reason the stains are given as saturated solutions in alcohol since they may easily be kept on hand in this form if the bottles are sealed to keep out moisture. Isopropyl alcohol was used for most of the work with this stain; however, ethyl alcohol should work equally well if allowance is made for its more rapid action.

The stain is applied from the intermediate xylol-alcohol clearing solution. The slide is flooded with the staining solution which is allowed to remain for one to two minutes until the stain is precipitated due to the evaporation of the alcohol. The completion of this precipitation is indicated by the clearness of the remaining solution and the greenish sheen of the precipitated stain. Evaporation should not be hastened by blowing on the slide since this usually results in uneven precipitation of the stain.

After the staining is completed, the solution remaining should be drained off and the slide flooded with the mordant for five to ten seconds. If the mordant is allowed to act too long, the eosin will be removed from the tissue. Differentiation is accomplished by washing with a mixture of two-thirds xylol and one-third absolute alcohol. This solution is best kept in a tightly stoppered bottle, since if left in a stender, the solution will lose its strength in a few weeks due to the

[1] The stains used in developing this technique were manufactured by the Coleman and Bell Company. The eosin was certified under No. CE9 and had a dye content of 89%, while the crystal violet, dye content 85%, was certified under No. CC9.

evaporation of the alcohol. Before mounting, the slide should be washed well in xylol.

This staining procedure may prove to be of some value not only because, with proper practice, it yields a sharply differentiated stain, but also due to the fact that there is a saving in time and materials because the slides must pass through fewer solutions than in the case of aqueous or weak alcoholic stains. In addition, since the staining time is uniform and no allowance need be made for the stain removed by the dehydrating and clearing solutions, skill and judgment are necessary only for differentiating the stain. The saving in time should be especially valuable to teachers who may find it necessary to make a number of slides for class work on short notice.

Contributions to a List of the Coleoptera of the Clark County State Forest

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For about ten years, students attending the Purdue University Summer Forestry Camp in the Clark County State Forest have made insect collections as a regular part of their camp work; the collections are used later by the students when they take a course in Forest Entomology. These collections have always contained a large proportion of beetles and the authors are attempting to work up a list of the Coleoptera of the Clark County Forest based largely upon this material. It has not been possible to retain for study more than a synoptic collection, except in a few families, and, therefore, few data upon the relative abundance of the different species are available. Certain groups, especially the Carabidae, have not been completely determined yet and are not included in the following list. The senior author has spent some time, varying from one day to three weeks, at the Forest every year since the students have made collections, and has secured specimens of a few species not represented in the student collections.

The Clark County State Forest is located in the "knob" or hill region of Clark and adjacent counties about 20 miles north of the Ohio River. However, the Purdue Forestry Camp site has always been located in the comparatively level eastern portion of the Forest which has an elevation of about 600 feet; and most of the specimens have been collected there. The elevation on some of the hill tops approaches 1100 feet. Charles Piper Smith published a list of the plants found in the Forest in the Report of the State Board of Forestry for 1903, but did not report anything of unusual interest except Virginia Pine (*Pinus virginiana*). Charles C. Deam, who is very familiar with the region, reports (in litt., Oct. 25, 1940) that "about the only departure from the usual mesophytic forest is on the knobs where chestnut oak and Virginia Pine are found". However, many plantings of trees not native to the region have been made in the forest and a forest nursery, growing native and some introduced species, has been maintained for many years.

The Forest is generally quite dry during the period that students attend camp but a number of lakes were established several years ago and these probably provide a habitat for certain species which did not previously occur within the area. The camp period covers a period of eight weeks beginning about the second week of June. Collecting by the senior author has been confined to this period also.

The material has been determined mostly by the junior author and examples of each species have been compared by one or both of the authors with named specimens in the Blatchley Collection, but doubtful or

unusual specimens have been submitted to specialists. However, all the specimens of certain groups have been determined by specialists—the Elateridae by Prof. E. C. Van Dyke, the Phyllophaga and a few related genera by Dr. Philip Luginbill, the Chrysomelidae by A. W. Trippel and the Curculionidae by L. L. Buchanan.

In the course of a forest insect survey of Indiana during the summers of 1937 and 1938 the senior author made some observations on the damage caused by certain species of beetles in the Clark County State Forest. The small black and red spotted leaf beetle, *Babia quadriguttata* (Oliv.), is always very numerous on oak, and to a less degree on hickory, in the Forest in June. Leaves of young trees and the more tender leaves of the tips of twigs of older trees are frequently entirely destroyed. However, this insect has not been found on oak seedlings in the nursery. The locust borer, *Cyllene robiniae* (Forst.), prevents the development of black locust plantings in the forest, although several such plantings have been made. Very few trees over two inches in diameter are free from borer attack and many under this size are infested. The locust leaf miner, *Chalepus dorsalis* Thunb., occurs in the forest but has not been observed in epidemic numbers, probably because the locust borer has prevented the development of any extensive plantings of black locust. An outbreak of the elm leaf beetle, *Galerucella xanthomelaena* (Schrank), was discovered in 1937 and information furnished by the director of the forest indicated that this insect had been causing extensive damage for about three years previous to that time. However, this insect appears to have a definite host preference among the different species of elms, and could not be found on the (native) elms in any part of the forest. At least three types of elms (English, Chinese and a native species), occur in the planting in which the epidemic was found; the first of these has been most severely attacked, being almost completely defoliated by first generation larvae (in June and early July). The second is also severely damaged, although slightly less than the first; but the native species has been but lightly infested. A few more or less causal observations on the life history of the elm leaf beetle in this locality were made. On June 16 (1938) larvae of several sizes, from less than half grown to mature, were noted, but most of them were mature and there were a very few pupae. On June 24 (1937) there were many mature larvae (only a few of other sizes) and many pupae. On June 28 (1938) mature larvae and pupae were abundant, less mature larvae were scarce, and there were a few adults, all apparently freshly emerged. Most of the adults were crawling on the trunks of the trees. The crevices in the bark of the infested trees were filled with pupae and mature larvae and the surface of the soil for three or four inches around the base of these trees were covered with them two or three layers deep. On July 26 (1937) there were many adult beetles, a considerable number of egg masses, some of which had hatched, and a few young larvae. On August 2-4 (1938) a relatively few partly grown larvae and a few adult beetles could be found on the trees. From life history studies in the Atlantic states, and from the development of the first brood, two or, possibly, three generations a year might be expected in southern Indiana. However,

the small numbers of larvae observed in August and the fact that little additional damage seems to occur after the first brood larvae mature in June indicate that the first brood adults enter hibernation quarters in July, or that some other factor prevents the development of most of the second generation.

At least one quite rare species is represented in the following list. Professor Van Dyke wrote (in litt., Feb. 3, 1939), "among your specimens were a few which merit a comment or so; the type and perhaps a specimen in the Drury Collection are the only other specimens that I know of *Ludius copei* (Horn)." Certain specimens of Fornax and Melanotus in the collections probably represent new species according to Professor Van Dyke.

The numbers and nomenclature of Leng's Catalogue and the four supplements are used in the following list.

List of Species

Cicindelidae

38 Tetracha virginica (L.)
42 Cicindela purpurea Oliv.
49 C. duodecimguttata Dej.
51 C. hirticollis Say
69 C. sexguttata Fab.
74 C. punctulata Oliv.
81 C. rufiventris Dej.
93 C. unipunctata Fab.

Dytiscidae

2351 Laccophilus maculosus (Germ.)
2580 Agabus gagates Aubé
2621 Rhantus confusus Blatch.
2636 Dytiscus fasciventris Say
2652 Acilius fraternus (Harr.)

Gyrinidae

2680 Dineutus assimilis Kirby
2700 Gyrinus analis Say

Hydrophilidae

2784 Berosus striatus (Say)
2797 Tropisternus striolatus (Lec.)
2805 T. glaber (Hbst.)
2807 T. lateralis (Fab.)
2867 Sphaeridium scarabaeoides (L.)

Silphidae

2913 Nicrophorus orbicollis Say
2914 N. marginatus Fab.
2918 N. pustulatus Hersch.
2920 N. tomentosus Web.
2922 Silpha surinamensis Fab.
2926 S. inaequalis Fab.
2928 S. americana L.

Staphylinidae

3874 Pinophilus latipes Grav.
3908 Gastrolobium bicolor (Grav.)
4533 Staphylinus maculosus Grav.
4543 S. fossator Grav.
4545 S. cinnamopterous Grav.
4552 Ontholestes cingulatus (Grav.)
4555 Creophilus maxillosus (L.)
4665 Tachinus fimbriatus Grav.

Histeridae

6596 Hister abbreviatus Fab.
6606 H. depurator Say
6836 Saprinus assimilis Payk.

Lycidae

6931 Celetes basalis Lec.
6945 Plateros modestus (Say)
6948 P. sollicitus (Lec.)

Lampyridae

6971 Lucidota atra (Fab.)
6975 L. corrusca (L.)
6984 Pyractomena angulata (Say)
6996 Photinus pyralis (L.)
6999 P. scintillans (Say)
7013 Photuris pennsylvanica (DeG.)

Cantharidae

7052 Chauliognathus marginatus Fab.
7055 Podabrus tricostatus (Say)
7056 P. rugulosus Lec.
7057 P. frater Lec.
7058 P. basillaris (Say)
7061 P. diadema (Fab.)
7062 P. modestus (Say)
7066 P. tomentosus (Say)
7068 P. brunnicollis (Fab.)
7092 Cantharis excavatus Lec.
7098 C. lineola Fab.
7105 C. flavipes Lec.
7121 C. bilineatus Say
7169 Trypherus latipennis (Germ.)

Cleridae

7544 Cymatodera bicolor Say
7566 C. undulata (Say)
7589 Ploeopterus thoracicus (Oliv.)
7595 Enoclerus quadriguttatus Oliv.
7597 E. rosmarus Say
7610 E. quadrisignatus Say
7637 Hydnocera unifasciata Say.
7647 H. humeralis Say
7675 H. verticalis Say
7677 H. pallipennis Say
7689 Isohydnocera tabida (Lec.)

Corynetidae

7716 Cregya oculatus Say
7719 Orthopleura damicornis Fab.

Lymexylidae

7740 Melittomma sericeum Harris

Mordellidae

7811 Mordella scutellaris Fab.
7814 M. octopunctata Fab.
7824 M. triloba (Say)
7859a Mordellistena comata cervicalis Lec.

Meloidae

7998 Epicauta trichrus (Pall.)
8018 E. vittata (Fab.)
8019 E. lemniscata (Fab.)
8024 E. cinerea (Forst.)
8024a E. cinerea marginata (Fab.)
8033 E. pennsylvanica (DeG.)
8042 Macrobasis unicolor (Kirby)
8044 M. flavocinereus Blatch.
8053 M. immaculata (Say)
8158 Zonitis bilineata Say

Rhipiceridae

8543 Zenoa picea (Beauv.)

Elateridae

8571 Alaus oculatus (L.)
8584 Chalcolepidius viridipilis (Say)
8596 Monocrepidius lividus (DeG.)
8601 M. vespertinus (Fab.)
8614 Aeolus dorsalis (Say)
8617 Pityobius anguinus Lec.
8618 P. murrayi Lec.
8625 Limonius griseus Beauv.
8633 L. quercinus (Say)
8635 L. basillaris (Say)
8662 Athous brightwelli (Kirby)
8667 A. cucullatus (Say)
8717 Ludius bivittatus (Melsh.)
8722 L. copei (Horn)
8728 L. signaticollis (Melsh)
8761 L. aethiops (Hbst.)
8776 L. splendens (Zieg.)
8780 L. inflatus (Say)
8797 L. divaricatus (Lec.)
8814 Hemicrepidius memnonius (Hbst.)
8853 Melanactes piceus (DeG.)
8861 Parallelostethus attenuatus (Say)
8866 Crigmus abruptus (Say)
8873 Orthostethus infuscatus (Germ.)
8883 Sericus silaceus (Say)
8934 Ampedus nigricollis (Hbst.)
8980 Megapenthes limbalis (Hbst.)
8996 Ischiodontus soleatus (Say)
9016 Melanotus corticinus (Say)
9019 M. decumanus (Er.)
9025 M. ignobilis (Melsh.)
9026 M. depressus (Melsh.)
9033 M. corticinus glandicolor Melsh.
9034 M. divaricarinus Blatch.
9035 M. communis (Gyll.)
9036 M. fissilis (Say)
9038 M. lixus Blatch.
9040 M. parumpunctatus (Melsh.)
9042? M. ?verberans (Lec.)
9054 M. gradatus Lec.
9055 M. opacicollis Lec.

Melasidae

9127 Isorhipis ruficornis (Say)
9146 Fornax badius (Melsh.)
9150 F. orchesides (Newn.)
9154 Microrhagus pectinatus Lec.
9179 Anelastes druryi Kby.
9180 Perothops mucida (Gyll.)

Throscidae

9191 Aulonothroscus punctatus Bonv.

Buprestidae

9272 Acmaeodera pulchella (Hbst.)
9286 A. tubulus (Fab.)
9291 Ptosima gibbicollis (Say)
9316 Chalcophora virginiensis (Drury)
9323 Chalcophorella campestris (Say)
9333 Dicerca divericata (Say)
9341 D. obscura (Fab.)
9342 D. lurida (Fab.)
9343 D. lepida Lec.
9349 D. tuberculata (Cast.)
9355 Cinyra gracilipes (Melsh.)
9363 Buprestis striata Fab.
9367 B. lineata Fab.
9372a B. nuttalli consularis Gory
9374 B. rufipes (Oliv.)
9405 Chrysobothris sexsignata (Say)
9407 C. scitula Gory
9436 C. blanchardi Horn

9461 C. dentipes (Germ.)
9466 C. Femorata (Oliv.)
9481 Actenodes acornis (Say)
9485 Eupristocerus cogitans (Web.)
9491 Agrilus bilineatus (Web.)
9498 A. acutipennis Mann.
9504 A. anxius Gory
9513 A. ruficollis (Fab.)
9520 A. egenus Gory
9523 A. arcuatus (Say)
9542 A. politus (Say)
9547 A. obsoletoguttatus Gory
9567 Pachyschelus laevigatus (Say)

Dryopidae

9603 Helichus lithophilus (Germ.)

Heteroceridae

9653 Heterocerus auromicans Kies.

Helodidae

9692 Cyphon ruficollis (Say)
9709 Scirtes orbiculatus (Fab.)
9716 Ptilodactyla serricollis (Say)

Dermestidae

9725 Dermestes caninus Germ.
9737 D. lardarius L.
9742 Attagenus piceus Oliv.
9824 Cryptorhopalum triste Lec.

Byrrhidae

9847 Nosodendron unicolor Say

Ostomidae

9990 Tenebroides americanus (Kby.)
9994 T. corticalis (Melsh.)

Nitidulidae

10101 Prometopia sexmaculata (Say)
10129 Cryptarcha ampla Er.

Cucujidae

10199 Silvanus planatus Germ.

Erotylidae

10279 Languria bicolor (Fab.)
10282 L. mozardi Latr.
10292 Acropteroxys gracilis Newn.
10301 Ischyrus quadripunctatus (Oliv.)
10308 Tritoma sanguinipennis (Say)
10327 Triplax festiva Lac.
10348 Megalodacne heros (Say)

Mycetophagidae

10491 Mycetophagus flexuosus Say
10508 M. obsoletus Melsh.

Lathridiidae

10701 Melanophthalma distinguenda Com.

Endomychidae

10726 Aphorista vittata (Fab.)
10753 Endomychus biguttatus Say

Phalacridae

10773 Phalacrus politus Melsh.

Coccinellidae

10930 Hyperaspis undulata (Say)
10972 Brachyacantha ursina (Fab.)
11082 Scymnus americanus Muls.
11158 Ceratomegilla fuscilabris (Muls.)
11162 Hippodamia tredecimpunctata (L.)
11163 H. parenthesis (Say)
11171 H. glacialis (Fab.)
11173 H. convergens Guer.
11178 Neoharmonia venusta (Melsh.)
11184 Coccinella novemnotata Hbst.
11189 Cycloneda sanguinea (L.)
11193 Adalia bipunctata (L.)
11196 Cleis picta (Rand.)
11202 Anatis quindecimpunctata (Oliv.)
11202a A. quindecimpunctata var. mali (Say)
11205 Neomysia pullata (Say)
11217 Chilocorus bivulnerus Muls.
11231 Epilachna corrupta Muls.

Alleculidae

11236 Lobopoda punctulata (Melsh.)
11255 Hymenorus obscurus (Say)
11267 H. discretus Casey
11307 Isomira sericea (Say)
11311 I. quadristriata Coup.

Tenebrionidae

12187 Opatrinus aciculatus Lec.
12295 Bolitotherus cornutus (Panz.)
12305 Diaperis maculata Oliv.
12309 Hoplocephala bicornis (Fab.)
12321 Platydema ellipticum (Fab.)
12328 P. subcostatum Cast, and Brll.
12343 Tribolium ferrugineum (Fab.)
12353 Uloma impressa Melsh.
12354 U. imberbis Lec.
12374 Hypophloeus parallelus Melsh.
12389 Merinus laevis (Oliv.)
12390 Xylopinus saperdioides (Oliv.)
12392 Haplandrus fulvipes (Hbst.)
12407 Alobates pennsylvanica (DeG.)
12408 A. barbata (Knoch)
12413 Tenebrio obscurus Fab.
12414 T. molitor L.
12446 Tarpela micans (Fab.)
12448 T. venusta (Say)
12485 Meracantha contracta (Beauv.)
12488 Strongylium tenuiolle Say

Lagriidae

12497 Arthromacra aenea (Say)

Melandryidae

12527 Penthe obliquata (Fab.)
12528 P. pimelia (Fab.)
12529 Sychroa punctata Newn.
12531 Eustrophinus bicolor (Fab.)
12570 Dircaea liturata (Lec.)
12580 Allopoda lutea (Hald.)

Anobiidae

12717 Trypopitys sericeus (Say)

Bostrichidae

12898 Lichenophanes armiger (Lec.)
12902 Bostrichus bicornis (Web.)
12919 Stephanopachys punctatus (Say)

Scarabaeidae

13048 Canthon laevis (Drury)
13057 Choeridium histeroides (Web.)
13059 Pinotus carolinus (L.)
13062 Copris minutus (Drury)
13080 Onthophagus hecate Panz
13084 O. janus Panz
13084a O. janus striatulus Beauv.
13087 O. cribricollis Horn
13119 Aphodius fimetarius (L.)
13184 A. distinctus (Müll.)
13202 A. prodromus (Brahm)
13233 Ataenius cognatus (Lec.)
13285 Odontaeus corniger (Melsh.)
13286 O. filicornis (Say)
13289 Eucanthus lazarus (Fab.)
13299 Geotrupes splendidus (Fab.)
13364 Serica sericea (Ill.)
19959 S. lecontei Daws.
13410 Diplotaxis liberta (Germ.)
13446 D. frondicola (Say)
13487 Phyllóphaga ephilida (Say)
13514 P. horni Sm.
13515 P. fervida (Fab.)
13517 P. drakei Kirby
13520 P. marginalis Lec.
13522 P. fraterna Harris
13535 P. balia (Say)
13538 P. hirticula (Knoch)
13540 P. ilicis (Knoch)
13544 P. crenulata (Froel.)
13709 Anomala binotata Gyll.
13720 A. flavipennis Burm.
13730 A. undulata Melsh.
13739 Pachystethus marginata (Fab.)
13755 Pelidnota punctata (L.)
13801 Ochrosidia immaculata (Oliv.)
13829 Dyscinetus trachypygus (Burm.)
13843 Ligyrus gibbosus (DeG.)
13902 Xyloryctes satyrus (Fab.)
13908 Dynastes tityus (L.)
13931 Cotinis nitida (L.)
13937 Euphoria fulgida (Fab.)
13953 E. sepulchralis (Fab.)
14010 Osmoderma scabra (Beauv.)
14012 O. eremicola Knoch
14025 Trichiotinus affinis (G.&P.)
14027 T. bibens (Fab.)
14031 Valgus canaliculatus (Fab.)

Cerambycidae

14080 Derancistrus taslei Buq.
14081 Derobrachus brunneus (Forst.)
14084 Prionus laticollis (Drury)
14089 P. imbricornis (L.)
14098 Distenia undata (Fab.)
14099 Smodicum cucujiforme (Say)
14153 Dryobius sexfaciatus (Say)
14177 Tylonotus bimaculatus Hald.
14181 Chion cinctus (Drury)
14190 Eburia quadrigeminata (Say)
14196 Romaleum atomarium (Drury)
14199 R. rufulum (Hald.)
14207 Hypermallus incertus (Newn.)
14211 H. villosus (Fab.)
14219 Elaphidion irroratum (L.)
14220 E. mucronatum (Say)
14227 Aneflomorpha subpubescens (Lec.)
14240 Anoplium cinerascens Lec.
14263 Pseudibidion unicolor (Rand.)
14271 Heterachthes quadrimaculatus (Fab.)
14286 Obrium maculatum (Oliv.)
14320 Stenocorus cinnamopterus (Rand.)
14321 S. schaumi Lec.
14343 S. cylindricollis (Say)
14395 Acmaeops directa (Newn.)
14426 Judolia cordifera (Oliv.)
14438 Brachyleptura rubrica (Say)
14469 Strangalepta vittata (Oliv.)
14508 Strophiona nitens (Forst.)
14514 Leptura emarginata L.
14543 Typocerus velutina (Oliv.)
14553 Ophistomis famelica (Newn.)
14556 O. luteicornis (Fab.)
14560 O. bicolor (Swed.)
14580 Necydalis mellita Say
14671 Cyllene robiniae (Forst.)
14672 Arhopalus fulminana (Fab.)
14674 Calloides nobilis (Harris)
14679 Xylotrechus colonus (Fab.)
14703 Neoclytus scutellaris (Oliv.)
14704 N. mucronatus (Fab.)
14745 Euderces picipes (Fab.)
14755 Rhopalophora longipes (Say)
14757 Stenosphenus notatus (Oliv.)
14795 Purpuricenus humeralis (Fab.)
14796 P. axillaris Hald.

14857 Batyleoma suturale (Say)
14895 Monochamus titillator (Fab.)
14910 Dorchaschema nigrum (Say)
14911 Hetoemis cinerea (Oliv.)
14915 Hammoderus tessellatus (Hald.)
14917 Goes tigrinus (DeG.)
14918 G. pulcher (Hald.)
14919 G. pulverulentus (Hald.)
14922 G. debilis Lec.
14932 Aegoschema modesta Gyll.
14943 Leptostylus aculifer (Say)
14943 L. tuberculatus (Fröl)
14960 Astylopsis macula (Say)
14961 A. guttata (Say)
14968 Leiopus variegatus (Hald.)
14975 L. punctatus (Hald.)
14976 L. fascicularis (Harris)
14984 L. cinereus Lec.
14995 Lepturges symmetricus (Hald.)
15001 L. querci Fitch
15021 Urographis fasciatus (DeG.)
15037 Dectes spinosus (Say)
15067 Ecyrus dasycerus (Say)
15069 Eupogonius tomentosus (Hald.)
15070 E. vestitus (Say)
15098 Hippopsis lemniscata (Fab.)
15114 Saperda tridentata Oliv.
15116 S. discoidea Fab.
15119 S. lateralis Fab.
15129 Mecas pergrata (Say)
15134 Oberea schaumi Lec.
15138 O. tripunctata var. mandarina (Fab.)
15145 O. basalis Lec.
15148 O. bimaculata (Oliv.)
15152 O. ocellata Hald.
15153 O. ruficollis (Fab.)
15158 Tetrops monostigma (Hald.)
15162 Tetraopes canteriator (Drap.)
15170 T. tetrophthalmus (Forst.)
15182 T. femoratus Lec.

Chrysomelidae

15262 Antiplus laticlavia (Forst.)
15267 Coscinoptera dominicana (Fab.)
15282 Babia quadriguttata (Oliv.)
15292 Saxinis omogera Lac.
15308 Griburius scutellaris (Fab.)
15451 Pachybrachys othonus (Say)
15459 P. trinutatus (Melsh.)
15462 P. luridus (Fab.)
15469 P. dilatatus Suffr.
15479 Cryptocephalus notatus Fab.
15479a C. notatus quadrimaculatus Say
15480 C. quadruplex (Newn.)
15480a C. quadruplex quadriguttulus Suffr.
15495 C. venustus (Fab.)
15495a C. venustus cinctipennis Rand.
15495c C. venustus ornatulus Clav.
15495d C. venustus simplex Hald.
15514 C. badius Suffr.
15530a Bassareus brunnipes clathratus (Melsh.)
15534 B. mammifer (Newn.)
15536 B. lituratus (Fab.)
15536b B. lituratus lativittis (Germ.)
15545 Nodonota tristis (Oliv.)
15549 N. puncticollis (Say)
15555 Colaspis brunnea (Fab.)
15574 Xanthonia villosula (Melsh.)
15614 Glyptocelis barbata (Say)
15625 Typophorus viridicyaneus (Cr.)
15626a Paria canella aterrima (Oliv.)
15626b P. canella gilvipes Horn
15626c P. canella pumila Lec.
15639 Labidomera clivicollis (Kirby)
15648 Leptinotarsa decemlineata (Say)
15655 Zygogramma suturalis (Fab.)
15665 Calligrapha similis Rogers
15669 C. elegans (Oliv.)
15708 Lina lapponica (L.)
15710 L. scripta (Fab.)
15749 Galerucella notulata (Fab.)
20192 G. cribrata (Lec.)
15754 G. xanthomelaena (Schrank)
15769 Diabrotica duodecimpunctata (Fab.)
15774 D. longicornis (Say)
15782 D. vittata (Fab.)
15850 Phyllecthrus gentilis Lec.
15854 Cerotoma trifurcata (Forst.)
15858 Blepharida rhois (Forst.)
15860 Pachyonychus paradoxus Melsh.
15865 Oedionychis gibbitarsa (Say)
15868 O. vians (Ill.)
15877 O. miniata (Fab.)
15889 O. quercata (Fab.)
15896 Disonycha quinquevittata (Say)
15901 D. glabrata (Fab.)
15907 D. xanthomelaena (Dalm.)
15910 D. mellicollis (Say)
15917 Haltica chalybea Ill.
15926 H. litigata Fall
15988 Orthaltica copalina (Fab.)
16022 Systena hudsonias (Forst.)
16028 S. taeniata blanda (Melsh.)
16113 Chalepus dorsalis Thunb.
16114 C. horni (Smith)
16129 Microrhopala vittata (Fab.)
16139 Chelymorpha cassidea (Fab.)
16150 Gratiana pallidula (Boh.)
16152 Chirida guttata (Oliv.)
16156 Metriona bivittata (Say)
16157 M. bicolor (Fab.)

Brentidae

16256 Eupsalis minuta Drury

Platystomidae

16299 Euparius marmoreus (Oliv.)
16303 Brachytarsus alternatus (Say)
16304 B. sticticus Boh.

Belidae

16324 Ithycerus noveboracensis (Forst.)

Curculionidae

16343 Eugnamptus collaris (Fab.)
16343a E. collaris nigripes (Melsh.)
16347 E. angustatus Hbst.
16351 Rhynchites aeneus Boh.
16365 Attelabus analis Ill.
16370 Pterocolus ovatus (Fab.)
16439 Apion procatum Boh.
16499 Phyxelis rigidus (Say)
16605 Pandeleteius hilaris (Hbst.)
16724 Brachystylus acutus (Say)
16728 Sitona hispidulus (Fab.)
16754 Hypera punctata (Fab.)
17156 Curculio caryae (Horn.)
17159 C. nasicus (Say)
17160 C. pardalis (Chttn.)
17219 Anthonomus signatus Say
17236 A. nigrinus Boh.
17359 Gymnetron tetrum (Fab.)
17518 Glyptobaris rugicollis (Lec.)
17735 Acanthoscelis curtus (Say)
17781 Ceutorhynchus sulcipennis Lec.
17842 Rhinoncus pyrrhopus Boh.
17856 Conotrachelus affinis Boh.
17858 C. seniculus Lec.
17872 C. naso Lec.
17877 C. posticatus Boh.
17890 C. anaglypticus (Say)
17899 Rhyssematus lineaticollis Say
17902 R. palmacollis Say
17919 Tyloderma foveolata Say
17929 T. punctata Casey
17986 Cryptorhynchus tristis Lec.
18031 Cossonus impressifrons Boh.
18035 C. corticola Say
18108 Calendra pertinax Oliv.
18114 C. costipennis (Horn.)

Scolytidae

18202 Chramesus hicoriae Lec.
18463 Ips grandicollis (Eich.)

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